Implementation Plan

Las Vegas Area Computer Traffic System

Prepared For

Nevada Department of Transportation
City of Henderson . City of Las Vegas . City of North Las Vegas
Clark County . Clark County Regional Transportation Commission
Federal Highway Administration

Prepared By

Barton-Aschman Associates, Inc.

Member of The Parsons Transportation Croup

September 1995

EXECUTIVE SUMMARY

The Las Vegas Valley has experienced the most rapid growth of any metropolitan region in the country. Along with annual growth rates over fifteen percent have come increasing traffic problems and air quality concerns. Public officials have aggressively pursued an ambitious program of public works improvements to address increasing traffic demand, including the construction of new roadways and the expansion of existing roadways. These improvements increase the supply of roadway capacity. Other improvements, such as the expansion of transit services, are designed to manage demand for the roadways by transferring travelers to more efficient transportation modes. Finally, local officials have established a program for improving the effectiveness of the existing roadway network by upgrading and enhancing the Las Vegas Area Computer Traffic System (LVACTS).

LVACTS was established in 1981 as one of the first multi-jurisdictional traffic signal systems in the United States. LVACTS was founded by the cities of Las Vegas and North Las Vegas, Clark County, the Clark County Regional Transportation Commission (RTC), and the Nevada Department of Transportation (NDOT) At the time of LVACTS' formation, a computerized system which centrally controlled all the traffic signals in the metropolitan area was installed. The existing system has now reached the intersection capacity, and cannot accommodate the additional traffic signals now being constructed in the Las Vegas Valley. Since the original system installation, the technology of traffic signal systems has also improved dramatically. As traffic congestion has increased, so has the need for these expanded capabilities.

Recognizing these critical needs, officials of LVACTS' participating agencies hired the consulting firm of Barton-Aschman Associates, Inc. in 1992 to study the feasibility of upgrading the existing system. Many traffic control, video surveillance, and communication system alternatives were identified and evaluated for the study. The recommended system alternative was then conceptually designed by the consultant team. The feasibility study and conceptual design produced preliminary cost estimates and a system layout. Based on these results, the RTC included the project in the Federally funded Congestion Mitigation and Air Quality (CMAQ) improvement program, which was established in the Intermodal Surface Transportation Efficiency Act of 1991. In 1993, NDOT, in cooperation with the LVACTS participants, again secured the services of Barton-Aschman Associates, Inc., to proceed with design and implementation of the system.

DESIGN APPROACH

Traditional signal systems have been designed from a traffic control center out. The existing system is an example of this highly centralized approach. The central computer directs, on a second-by-second basis, the individual actions of all 475 traffic signals that are now part of the system. This approach requires a large central mainframe computer and demands a very reliable communications capability between the central computer and the intersection controllers.

The new system follows an innovative approach, where all the individual traffic signal control is contained at the intersection. This decentralized, or distributed intelligence will allow the system to provide reliable operation even when the communications system fails. Also, the distributed approach will allow the replacement of the existing mainframe computer with a network of inexpensive and easy-to-maintain microcomputers. The following sections briefly describe the major design components of the system.

LOCAL INTERSECTION CONTROL

The distributed approach requires a very powerful traffic signal controller at each intersection. The new system will be the first large-scale implementation of the new Caltrans 2070 Advanced Transportation Controller, which has been under development around the country since 1991. The new controllers are based on powerful and reliable industrial microcomputers now proven in the process control and communications industries. These controllers will be installed at all traffic signal locations within the jurisdiction of the LVACTS participating agencies during 1996.

VIDEO SURVEILLANCE

In addition to increasing the features and reliability of the traffic signal control system, the design concept has incorporated a video surveillance system. Closed-circuit video from 48 critical locations around the Valley will give operators the chance to observe traffic conditions and make adjustments from the downtown Traffic Management Center. Also, the LVACTS agencies will be able to monitor traffic from jurisdictional traffic management centers located at each agency. By allowing system operators to view more than one location, and by eliminating much of the driving time now required for traffic observation, the video system will greatly increase the effectiveness of the LVACTS staff.

COMMUNICATIONS

To provide the LVACTS operators with access to the intersection controllers and video cameras, system designers have devised a two-tiered communications network. The system has been divided into nine regions, and all the intersection controllers within each region will be tied to a hub located within the region. These regional hubs will be connected into a backbone communications system using high-frequency microwave. The microwave hub sites will consist of small high-performance microwave antennas mounted atop conventional steel utility poles. Unlike lower frequency long-haul microwave equipment used by the telecommunications industry, the LVACTS microwave components use very low power transmitters feeding small antennas. The antennas are much smaller than those used for cellular telephones which are located at frequent intervals throughout the region.

The Nevada Department of Transportation has selected a contractor to begin construction of the $3.5 million backbone communications system. Construction on the system is scheduled for completion in mid-1996.

Several different technologies will carry video and controller signals from the cameras and intersections to their respective hubs. These technologies include data radio, ultra-high-frequency microwave, fiber-optic cable, and special equipment designed to move video along the existing copper cables that are used by the existing system. In total, the upgraded LVACTS communications network will showcase the most advanced technologies available for traffic management systems.

TRAFFIC OPERATION

Of course, the purpose of a traffic signal system is to provide the capability to move traffic as efficiently as possible. Traffic signals cannot add capacity, but they can allow traffic to make best use of the capacity by distributing it fairly to all movements. The current system imposes constraints on coordinated signal timing because of limited operational capabilities. With the new system, these constraints will be resolved and the system operators will therefore have the opportunity to systematically improve the operation of the area’s busiest arterial streets. The ongoing project includes a major work element to collect detailed traffic data and develop new signal operation within the new system. This work is scheduled for mid-1996.

AGENCY RESPONSIBILITIES

Several local, state, and federal agencies have participated in the development of the LVACTS Upgrade. With so many participants, coordination of administrative, design, construction, operations, and maintenance responsibilities becomes paramount. These various responsibilities are detailed within this report. The following paragraph briefly summarizes the local agency responsibilities.

LVACTS staff operate and maintain the system on a day-today basis. LVACTS staff are overseen by the Operations Management Committee (OMC). The OMC consists of local agency representatives which set the policy for the system operation and provide funding for continuing operations and maintenance. The City of Las Vegas is designated as the central operator for the system. In this capacity the City is responsible for providing LVACTS staff personnel and administrative support. The City of Henderson, the City of North Las Vegas, and Clark County will operate and maintain their respective jurisdictional Management Centers and local signalized intersection hardware. NDOT is providing administrative oversight on funding and construction of the system.

ORGANIZATION OF REPORT

This Implementation Plan for the Las Vegas Area Computer Traffic System (LVACTS) upgrade, has been prepared in accordance with 23 Code of Federal Regulations 655.409 (f) (NS 23 CFR 655.409 (f)). The upgrade project highlighted herein conforms to the Clark County Regional Transportation Commission's *Transportation Improvement Program* (TIP) and Nevada's *Statewide Transportation Improvement Program* (STIP). This plan covers all implementation activities prior to, during, and after construction. Specifically, this plan highlights the legislative issues, the system design, procurement methods, construction management procedures, the system start-up plan, system operations and maintenance, institutional arrangements, and the systems personnel and budget resources.

TABLE OF CONTENTS

LIST OF TABLES / LIST OF FIGURES

I. INTRODUCTION

This *implementation* Plan for the Las Vegas Area Computer Traffic System (LVACTS) upgrade, has been prepared in accordance with 23 Code of Federal Regulations 655.409 (f) (NS 23 CFR 655.409 (f). The upgrade project highlighted herein conforms to the Clark County Regional Transportation Commission's (RTC) *Transportation Improvement Program* (TIP) and Nevada's *Statewide Transportation Improvement* Program (STIP). The RTC is the *Metropolitan Planning Organization* (MPO) for the Las Vegas urbanized area. This plan covers all implementation activities prior to, during, and after construction. Specifically, this plan highlights the legislative issues, the system design, procurement methods, construction management procedures, the system start-up plan, system operations and maintenance, institution arrangements, and the systems personnel and budget resources.

PROJECT HISTORY

The Las Vegas Area Computer Traffic System (LVACTS) was established in 1981 as one of the only multi-jurisdictional traffic signal systems in the United States. LVACTS is managed by an internal staff and is overseen jointly by the cities of Henderson, Las Vegas, and North Las Vegas, Clark County, the Clark County RTC, and the Nevada Department of Transportation. The combined agencies comprise LVACTS' Operations Management Committee (OMC) and provide all operations and maintenance funding. The primary purpose of the original system was to provide coordination between traffic signals along the major streets. Surprisingly few multi-jurisdictional systems have been established, and this is regrettable, because inherent in the concept is a forced cooperation which results in signal coordination becoming almost solely a technical function rather than one in which political agendas are plied.

LVACTS' continuing evolution has reached a pivotal point. The original system was based upon the UTCS (first generation) concept promoted by the Federal Highway Administration of the U.S. Department of Transportation. The system became operational in 1983 and was one of the last UTCS system installed nationwide. After the first few years of operation, the system began to exhibit numerous communication and control system-related problems which were affecting both the efficiency and effectiveness of traffic control within the Las Vegas region. With the region continuing to grow at one of the fastest paces in the country, new levels of congestion, pedestrian movements, and general dynamism of traffic requires increased levels of sophisticated control.

Recognizing the need to improve the signal system, LVACTS retained a consultant team led by Barton-Aschman Associates, Inc. to examine the available options for upgrading the present system. This Feasibility Study focused on the development and evaluation of several alternatives for upgrading the LVACTS system. In essence, this project was concerned with reviewing present and future conditions and needs and developing a feasible, yet cost-effective approach for addressing these needs and issues. The OMC oversaw the project's progress and helped develop as well as select the preferred upgrade alternative. Specifically, the project consisted of an assessment of growth and expansion issues for the system; a determination of the deficiencies associated with the existing system; a review of alternatives available in the areas of control, communications, and surveillance; visits to selected systems to gain firsthand insights into actual practices and perceptions of other agencies; development of goals, objectives, and functional requirements of an upgraded system; development and evaluation of candidate upgrade alternatives; and the preparation of a staged implementation program.

The next project phase was the Conceptual Design. This design was prepared to assess the viability of the preferred alternatives identified in the Feasibility Study. The Conceptual Design also provided the system designer the opportunity to provide a preliminary cost estimate so that project funding levels could be established on the Statewide Transportation Improvement Program.

The Final Design addressed several tasks. The first was a detailed evaluation of many technologies being proposed for the system upgrade. Among these evaluations were vehicle detection systems, video surveillance systems, communications media, and control hardware. Final P,S&E was also prepared under this phase. Other products of this phase included all specifications and estimates, the FHWA Implementation Plan, a control hardware inventory, a photolog summary of all signalized intersections, and series of staff forums. Throughout the system upgrade process, many reports and technical memorandums were written, detailing study results, recommendations, and agreement on strategies. This process kept the OMC as a primary participant in the design and created an "ownership" which would not have otherwise been possible. The titles of these documents have been summarized in **Table 1.**

The current Implementation phase consists of timing plan development, implementation, and fine-tuning, central and local control software development, system testing and integration of all components. Finally, the consultant team will provide on-site construction administration support services as part of NDOT's construction oversight.

AIR QUALITY

The Las Vegas Valley has enjoyed tremendous growth from less than 250,000 population to over one million people during the life of the existing system. The current growth rate exceeds fifteen percent per year, making Las Vegas the fastest growing metropolitan region in the country. This rapid growth has created a massive increase in traffic demand, with the corresponding explosive growth in traffic congestion and vehicle emissions.

Because vehicular traffic is the chief cause of mobile-source air pollutants, the growth in transportation demand has had a severe impact on air quality. With the passage of the Clean Air Act Amendment of 1990, the Environmental Protection Agency (EPA) has imposed strict standards for air quality in metropolitan areas. In identifying projects that could improve air-quality, the upgraded signal system was given the highest priority for all CMAQ-funded projects in the STIP.

The upgrade of LVACTS will be an important element in the Las Vegas area's effort to attain National Ambient Air Quality Standards for carbon monoxide and fine particles. The Las Vegas area's failure to attain these standards has placed it under close scrutiny of the Environmental Protection Agency. Classified as a "moderate" non-attainment area for carbon monoxide, Las Vegas must attain the standards by the end of 1996. An upgraded signal system will allow for more sophisticated and efficient levels of traffic control. With the expanded capacity, the system will control all signalized intersections, thereby minimizing stops, delay, and air pollutants throughout the valley.

The upgraded system will also improve travel speeds throughout the region thereby reducing mobile source pollutant emissions. Recent studies have shown a decrease in travel times ranging between five and fifteen percent following the implementation of optimized system timing plans. Because the LVACTS system currently exists, it is expected that improvements in travel times would be less than those achieved following implementation of a completely new system. Conservatively assuming a reduction in travel times ranging from two percent to seven percent, mobile source carbon monoxide emissions could be reduced (compared to a continuation of the existing system) approximately three to ten percent with the upgraded system.

Table 1. LVACTS UPGRADE DOCUMENTATION SUMMARY			
REF NO.	**TITLE**	**REF NO.**	**TITLE**
1	Feasibility Study for the Las Vegas Area Computer Traffic System Upgrade Alternatives	LV-29	Meeting Minutes Staff- Forum #2
2	Conceptual Design Study for the Las Vegas Area Computer Traffic System Upgrade Alternatives	LV-30	System Detector Design Kick-Off Meeting Minutes
LV-1	System Architecture	LV-31	Equipment Purchase for LVACTS Project
LV-2	Local Controller Software	LV-32	Preliminary Specifications for Backbone Communications
LV-3	Criteria for Controller Changeout	LV-33	Local Controller Software Requirements
LV-4	Progress Report on Caltrans 2070 Project	LV-34	Refined Implementation Plan Cost Estimate Update
LV-5	Meeting Minutes -Staff Forum #1	LV-35	Final Draft of Microwave Backbone Specification
LV-6	Software Platform	LV-36	System/Count Detector Locations
LV-7	Communications System	LV-37	Refined Implementation Plan Update
LV-8	Revised LV-7	LV-38	Final Video Surveillance Camera Locations
LV-10	Revised OMC-2 (LV-3)	LV-39	Visual Image Processing Evaluation Status Report
LV-11	Video-Imaging Demonstration Location	LV-40	Refined Implementation Plan Cost Estimate Update
LV-12	Refined Implementation Plan	LV-42	900 MHz Evaluation Criteria/Procedures
LV-13	Hub-to local Communications Requirements	LV-43	LVACTS Upgrade Phase 3 Completion Schedule
LV-14	Signalized Intersection inventory Database	LV-44	Demonstration Corridor Status Report
LV-15	Proposed Hardware for Central Network	LV-45	Evaluation of Visual Image Processing Equipment
LV-16	18 GHz Microwave Communications Recommendations	LV-46	Test of 900 Mhz Radio V System
LV-17	Video-Imaging Evaluation Criteria	LV-47	Project Status/Schedule Update
LV-18	Initial Evaluation of Hub-to-Local Communication Media	LV-48	Evaluation of Video Surveillance Equipment
LV-19	Visual Displays for TMC and JMCs	LV-49	Final Status Report on Demonstration Corridor
LV-20	Map Software	LV-50	Use of Camera and Communications Equipment From Demonstration Corridor
LV-21	LVACTS Expanded System Map	LV-51	Use of Agency Force Accounts
LV-22	Video Surveillance Camera Locations	LV-52	Update of Agency Force Accounts
LV-23	Candidate Locations for Count Detectors	LV-53	Revised System Detector Summary
LV-24	LVACTS Signalized Intersection Inventory Database	LV-54	Request for Equipment Purchases
LV-25	Project Funding RequirementsUpdate	LV-55	Disposition of P,S,&E Comments
LV-26	Evaluation of Video Surveillance Equipment	LV-56	Status of FCC License
LV-28	Recommendations for a Demonstration/Evaluation Corridor	LV-57	LVACTS Staffing Issue and Recommendations

NOTE: Memorandums LV-9, LV-27, and LV-41 are not used

II. LEGISLATIVE ISSUES

The Las Vegas Area Computer Traffic System (LVACTS) came into being with the signing of the Las Vegas Area Traffic Control Svstem Agreement (Hwy. Agreement No. P547-80-012 on the 21st day of January, 1981. This agreement and it's amendments are illustrated in **Appendix A.** The original participants of this system included the City of Las Vegas , the City of North Las Vegas, Clark County, the Clark County Regional Transportation Commission, and the Nevada Department of Transportation. Senior technical staff representatives from these agencies are known as the Operations Management Committee (OMC) which sets the policy for the system operation. The City of Las Vegas is designated as the central operator for the system. In this capacity the City is responsible for staffing LVACTS for daily operations and maintenance of the system.

Three amendments have been approved since the original agreement. The first amendment, dated the 19th day of March, 1991, authorized the central operator to engage the services of one or more consultants for evaluation, design, and implementation system upgrade. The second amendment, dated the 16th day of July, 1991, gave maintenance responsibilities of all communication components to the system manager. Finally, the last amendment, dated the 12th day of July, 1995, added the City of Henderson to LVACTS.

Annual operating expenses to sustain regular system operation are shared by the four jurisdictions, apportioned according to the number of signalized intersections under system control. Funding for the upgrade of the system are coming from state and federal sources.

No other state or local laws, regulations, and/or policies significantly affect the operation of LVACTS.

III. SYSTEM DESIGN

SYSTEM DESIGNER

The upgrade of the Las Vegas Area Computer Traffic System has been conducted over a series of phases. The major phases of this project include a Feasibility Study **(Phase 1),** Conceptual Design **(Phase 2),** Final Design (Phase 3), Implementation (Phase 4), and Construction Administration (Phase 5). Barton- Aschman Associates, Inc. has led the consultant team for each of these phases.

Table 2 highlights the major contributions of the consultant team members for each project **phase. A** shaded field indicates that the consultant did not participate in that particular phase of the project.

TABLE 2. LVACTS CONSULTANT TEAM MEMBERS BY PROJECT PHASE

Consultant Firm Name	Project Phase				
	1	2	3	4	5
Barton-Aschman Associates, Inc. (Project Management, System Design)	X	X	X	X	X
Kessmann & Associates, Inc. (Computer hardware/software)	X	X	X	X	
Ralph M. Parsons Company (backbone communications)			X (1)	X	X
Louis Berger & Associates, Inc. (architectural design, drafting, data Collection)			X	X	X
Meyer, Mohaddes, Associates, Inc. (communications)	X	X	X (1)		
Echelon Industries, Inc. (component evaluation)	X				
SEA, Inc. (data collection)	X	X			

(1) During the middle of **Phase 3 - Final Design**, Meyer, Mohaddes Associates, inc. was replaced with the Ralph M. Parsons Company.

Questions related to the LVACTS upgrade can be sent to 1) LVACTS, 418 N. 8th Street, Las Vegas, Nevada, 89101, or 2) Barton-Aschman Associates, Inc., 5485 Belt Line Road, Suite #199, Dallas, Texas, 75240.

SYSTEM DESIGN LIFE

The design life of the upgraded system is estimated at ten years due to the anticipated life expectancy of the system's components and due to the anticipated technological advances anticipated over the next decade. An exact design life is impossible to quantify. Many of the system components, although reliable, have only been in use for a short time. No accurate information on mean-time-between-failures for these components is available. The design life of similar electronic components is conservatively estimated at ten years. As was seen with the existing LVACTS upgrade, today's technology and traffic operations abilities greatly exceed those of over ten years ago. In ten more years technological advances and our ability to efficiently control traffic should increase dramatically. These advances will enable the future system designer to realize significant improvements.

SYSTEM COVERAGE

With the recent addition of the City of Henderson to LVACTS, coverage of all signalized intersections within the Las Vegas Valley is complete. LVACTS currently operates 475 signalized intersections. An additional 118 existing signalized intersections await inclusion into the new system. Due to rapid population growth the local transportation agencies anticipate approximately 350 new traffic signals to be constructed over the next ten years. Total coverage of the Las Vegas Valley traffic signals will probably exceed 900 intersections in ten years. All existing and near-future traffic signals are highlighted on the system maps found in **Appendix B.**

DESIGN AND OPERATIONS / MAINTENANCE PHILOSOPHY

The design of the LVACTS upgrade has been evolving over the last few years. The blueprint for the new system was prepared during the feasibility and conceptual design portions of the project. Fortunately, the design process was flexible enough to take advantage of significant technological advances over the last two years. Underlying all these technological advances were some basic design guidelines that influenced the final operations and maintenance of the system.

DESIGN GOALS AND CRITERIA

Using the insights gained from the visits to other signal systems and the discussions with their staff, throughout the development of the conceptual design, and during detailed discussions with LVACTS staff members, several goals emerged which were critical in the development of the system upgrade. These goals were:

- Maximize reliability and fail safe operations.
- Maximize the ability of the system to monitor itself and report on system performance.
- improve traffic operations/flows.
- Minimize negative impacts of disruptions related to implementation.
- Design the system for ease of additions, deletion, and/or upgrades.
- Maximize adaptability of the system to changing short and long term patterns and needs.
- Eliminate proprietary and non-standard hardware components from the system.
- Control installation costs, especially by allowing staged construction.
- Eliminate shortcomings in current signal system algorithms.

These design goals were expanded by the LVACTS Operations Management Committee (OMC) to include the design criteria of maximizing reuse of the existing twisted-pair cable plant, minimizing the construction of new underground communications cable, and providing a comprehensive video surveillance system. The reasons for these additional design criteria are briefly described below.

In recent years, the existing twisted-pair cable plant has been subject to frequent intrusions. Construction in the Las Vegas Valley has become widespread, and the maintaining agencies have had to devote significant resources to keeping the infrastructure in good working order. Because of the significant investment in the existing infrastructure, the use of the existing copper wire plant was mandated to be maximized in the new system.

While the system operators were committed to the existing plant, they were not enthusiastic about extending the existing wire and thus increasing their maintenance requirements. Therefore, the design criteria of no new cable was established by the OMC. Extensions of the system to include intersections not reached by the existing cable were required to be uninterruptable by backhoe.

Despite the limitations of these requirements, the system operators provided the further challenge to include a significant video surveillance capability at major intersections around the valley. The addition of video surveillance increased the required communications capacity by several orders of magnitude beyond the capabilities of the existing twisted-pair cable network.

These new design criteria have been met by exploring communications alternatives on the leading edge of technology and/or not generally used in the traffic industry. An important point is that the system designers avoided technologies that are unproven in the field, but worked with a variety of technologies not before combined into one integrated design for a traffic system. All of these technologies, however, conform to a few important design principles.

These factors are entirely consistent with current trends in the computer industry, and suggest a system design that will place the new LVACTS system at the leading edge of the traffic control industry. Successful implementation of the new system will produce a technological approach which very well could become the new “standard” in the industry.

PRINCIPLES OF DESIGN

Maintaining open communications, utilizing simple technologies, and providing a cost-effective system were three design principles used in this system upgrade. The most important principle is to maintain open communications standards. Many communications techniques in past systems have been designed around specific technologies. Modern systems will require communications standards that do not depend on any particular communications medium. Medium independence has been critical in the design of the LVACTS upgrade.

A second principle is to use the simplest technology that will provide the needed capabilities. The system designers have avoided the temptation to make the new system a showcase for technological sophistication for the sake of impressiveness. This temptation is sometimes overwhelming, but any system must be maintainable by the operating agencies or the system’s sophistication will be precluded from serving the motoring public.

Finally, a significant effort went into assessing the required communications reliability in the new system. Increased reliability adds cost, and a project with a limited budget will provide fewer features if the designed-in reliability is excessive. By placing the power of the system in the local controller, and by avoiding centralized real-time control, the system could be designed around a lower reliability level. This lower reliability opened up a number of options, such as a broadband microwave, which would not be reliable enough for a system that depended on the communications plant to maintain signal coordination.

With these principles in mind, the system designers developed a multilevel communications scheme that provides all these requirements. The design includes a backbone which provides a high-capacity ring around the Las Vegas Valley. The backbone consists of twelve hubs connected by broadband microwave communications. The backbone connects the central computers with the twisted-pair network at strategic locations. Each major branch of the existing cable and the City of Henderson is served by a hub, and thus the cable system is no longer required to provide trunk communications. The existing cable serves as the major portion of the distributed communications network, but has been extended using one of several techniques which are discussed in detail in later sections.

STAFF FORUMS

All too frequently, traffic signal systems have been designed and implemented with little or no input from the technicians who are relegated to operate and maintain the system. In an effort to avoid this problem, a series of staff forums were conducted to address key elements of the system and to seek input from the key users. These forums were specifically geared toward the technicians from each agency. Topics of these staff forums included backbone communications technology, local controller hardware and software, local communications technology, and video surveillance. These staff forums allowed the technicians the opportunity to participate in the systems formation and provide valuable design, operations, and maintenance input to the system designers. Without the support of LVACTS and local agency operations and maintenance staff, this system would not be able to operate at maximum potential.

SYSTEM ARCHITECTURE

DISTRIBUTED PROCESSING

The approach in refining a system architecture strategy was to define the prospective levels of processing and the functions required in each level. This approach is consistent with the fundamental principle of distributed processing, which is to assign tasks to system components at the location where the process is needed.

In the existing LVACTS system, the central system must communicate with the local controllers once or twice each second to maintain control over the signal timing. When communications to the central system goes down, or the system must be brought down for preventive maintenance or repairs, control over the local intersections is lost, and the local controllers must run as free actuated machines without the discipline of coordination timings.

Following principles of distributed processing, the local controller should be responsible for all signal timing, both free and coordinated, under the loose supervision of the central system. This leaves the central system free to perform other tasks in direct assistance to the system operators, such as surveillance, without damaging operation on the street.

The central system itself has many responsibilities, including communications, database management, surveillance, and the like, but does not have the responsibility of real-time control. The various functions of the system are distinct, and suggest a PC-size machine for each function, networked together. The hub computers will have heavy communications responsibilities, for example, but will not be required to display graphics. The user terminals in the various control centers, however, will have the responsibility for displaying graphics, but will not be required to handle downstream communications. In this scheme, processes are distributed along functional lines, rather than along hierarchical lines as in other distributed systems. The advantage to a distributed approach is that no machine is given more to do than can be done by a microcomputer. Consequently, each machine will be a readily available industry-standard component. The communication processes will be distributed as shown in Table 3 and as illustrated in **Figure 1.**

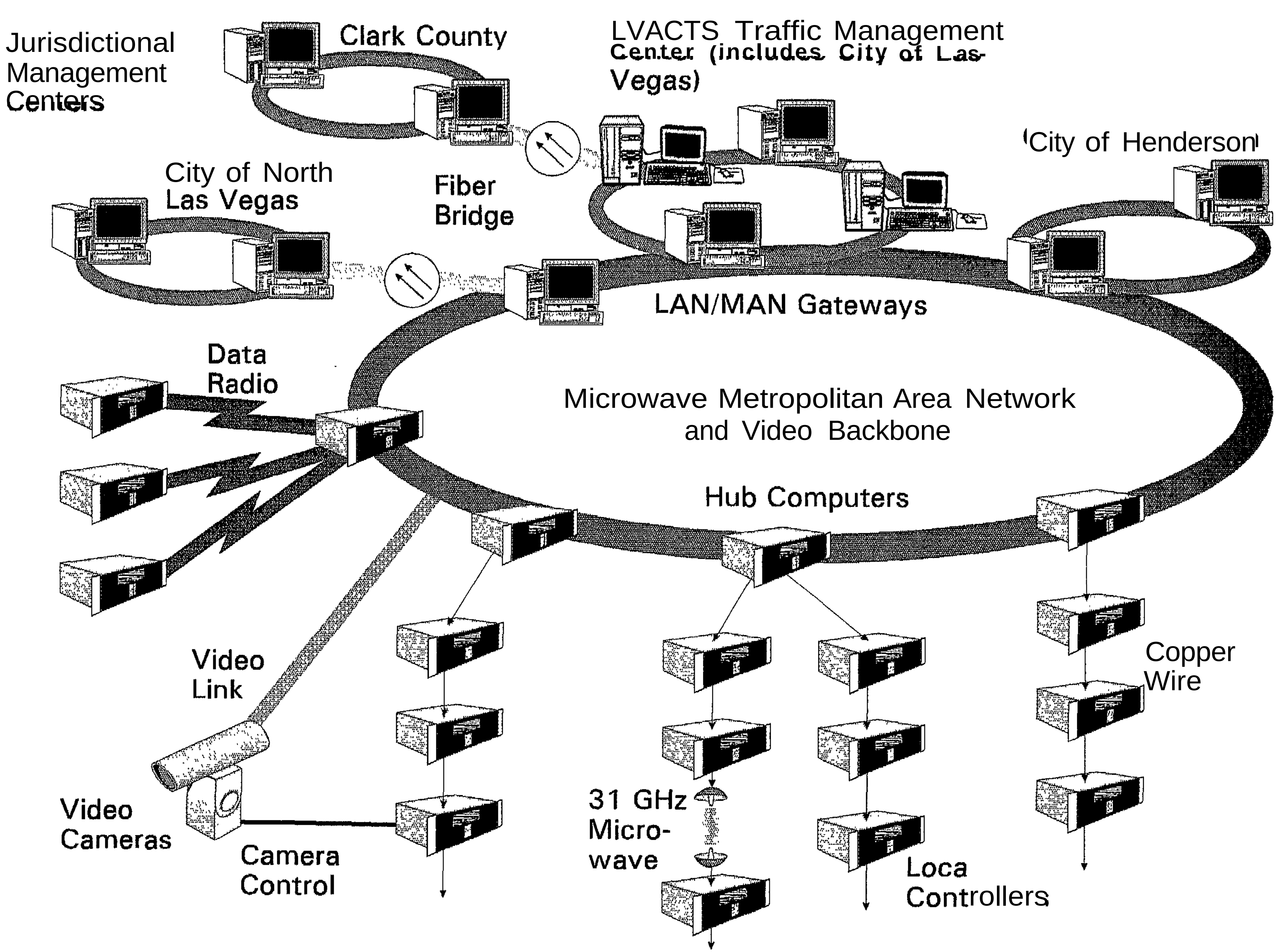
Some nice features emerge from the process distribution as proposed. The most obvious one is that the bulk of dealing with local controllers rests with the local controllers themselves and the hub computers. Expanding the system therefore automatically increases the capacity of the control system.

TABLE 3. LVACTS COMMUNICATIONS PROCESS DISTRIBUTION

IAN CONNECTION	**User Terminal** – PC/ DOS /Windows Platform • Graphical Display • User Interface **Central(s)** – PC/Windows NT Platform • Database - Control Data - Traffic Data • Display • Communications Oversight • Video Surveillance Control **Hub Computer** – VMEbus with hardened PC / DOS network compatible • Broker Communications • Historical Event Log • Historical Traffic Data • Poll Locals (for data updating - NOT Control) • Video Surveillance Switching
9600 BAUD SERIAL ON TWO TWISTED PAIRS	**Local Controller** –VMEbus-based Caltrans 2070 with NEMA I/O • Communications • Signal Timing (all aspects) • System Detector Processing • Local Data Storage • Event Scheduler • User Interface

As hubs reach their limit (currently planned to be 250 intersections) new hubs can be installed with little impact on the central equipment. Therefore, the build-out capacity of the system becomes a by-product of other requirements, and the capacity of this strategy would be measured in thousands of intersections.

Figure 1. LVACTS System Architecture



Unlike the existing system, which has nearly reached the intersection capacity, the new system cannot be outgrown by the Las Vegas Valley,

COMMUNICATIONS CONSIDERATIONS

The backbone microwave network currently under construction will consist of twelve hubs, one of which will be located at the Traffic Management Center. The other eleven hubs will be placed at geographically strategic locations around the valley. The existing twisted-pair cable plant will be reconnected to separate it into distinct regions. A preliminary review of prospective hub locations indicates that many of the hub region boundaries already exist naturally as an outgrowth of cable installation so far. The local controllers within the region will be connected to a hub using the cable in the ground (or new communications media in areas not currently served by twisted-pair cable). The hubs will have a broad-band communications link (or links) with the TMC. Likewise, the TMC will communicate with the jurisdictional management centers by broad-band link. The current layout for the microwave backbone is shown in **Figure 2.**

The regional hub approach removes from the twisted-pair network the task of handling long trunk lines. Consequently, interruption of the twisted-pair cable will affect a much smaller number of intersections, making the system more reliable. Coupled with the ability of the local controllers to control the intersections in coordination without central or hub supervision, removing trunk communications from thetwisted-pair network will greatly reduce the probability that drivers will be faced with uncoordinated signals because of construction or malfunctions at the TMC.

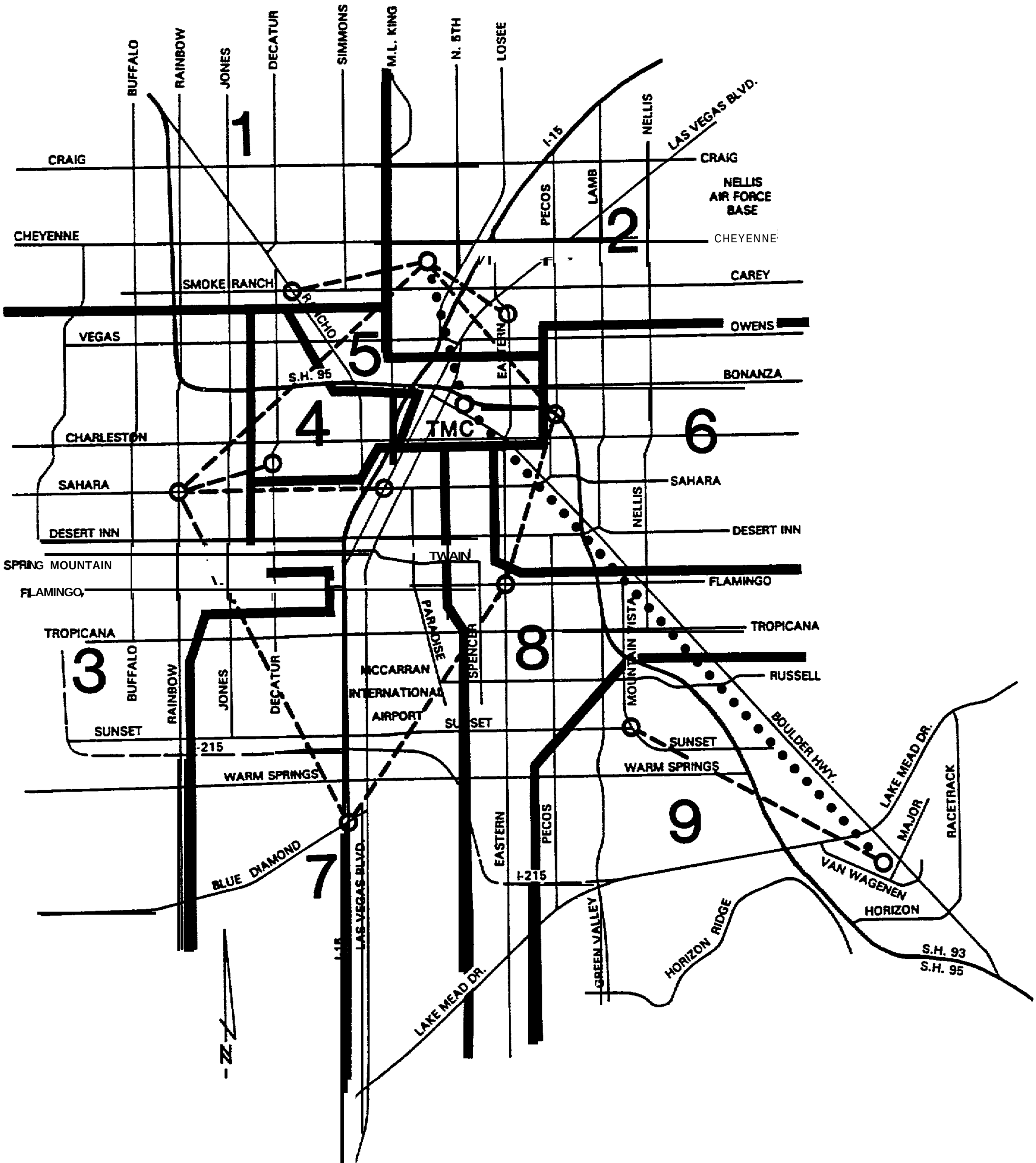
Another advantage to microwave is the ease of installation. Media requiring coaxial or other broad-band cable in the ground over long distances would require extensive construction. With cable in the ground, reuse of the existing conduit system is desirable. From a practical standpoint, however, adding cable to existing conduit is unpredictable at best. Unfortunately, many problems such as crushed or kinked conduit will not permit fishing additional cable. The practical problem is that conduit problems cannot be identified until construction time. A high frequency of these problems would cause undesirable construction delays and overruns.

Microwave is a proven technology for broad-band communications. Nearly all radio and TV stations previously or currently use microwave to transmit their signal from the studio to the transmitter site. Also, many telephone services, both local and long distance, use microwave for their trunk networks.

By employing open communications standards and architecture, and by carefully assessing real reliability needs, the designers of the new Las Vegas Area Computer Traffic System have formulated a multi-media communications approach that will allow widespread data and video signals to be returned to the control center extremely cost-effectively. The project will also provide advanced capabilities for a traditional cost. Finally, maintenance of the system is made easier by employing wireless devices that do not require in-ground maintenance of extensive linear infrastructure.

INTEGRATION POTENTIAL WITH OTHER SYSTEMS

The integration of LVACTS with a freeway traffic management center is an issue routinely being discussed among the local agencies and interested parties. The Director of the Nevada Department of Transportation has expressed his willingness to co-locate a freeway traffic management center with LVACTS. A consultant is currently addressing the issue of integrating many agencies and user groups in the Las Vegas ITS far/y Deployment P/an. The LVACTS system was designed to provide flexibility and accommodate expansion,



LEGEND

- - - - 18 GHZ Link

● oeoo 13 GHZ Link

——— Regional Boundaries

O Microwave Hub

FIGURE 2

MICROWAVE BACKBONE COMMUNICATIONS LAYOUT

as well as integration with other systems. The proposed LVACTS system is designed with a distributed architecture which allows significant expandibility. A freeway traffic management center could easily be integrated with LVACTS.

SYSTEM COMPONENTS AND FUNCTIONS

DEMONSTRATION CORRIDOR

From the outset of the system design process, the design requirements and expectations of the OMC members were to push the envelope of technology. Many of the technologies identified during early stages of design had little or no track record within the traffic systems field. With this in mind, a demonstration corridor was conceived where technological advancements in broadband communications equipment, non-intrusive detection equipment employing visual image processing, and enhanced video surveillance equipment could be evaluated for use in the LVACTS upgrade. The West Sahara Avenue corridor was selected from among many candidate locations since the corridor met the following criteria:

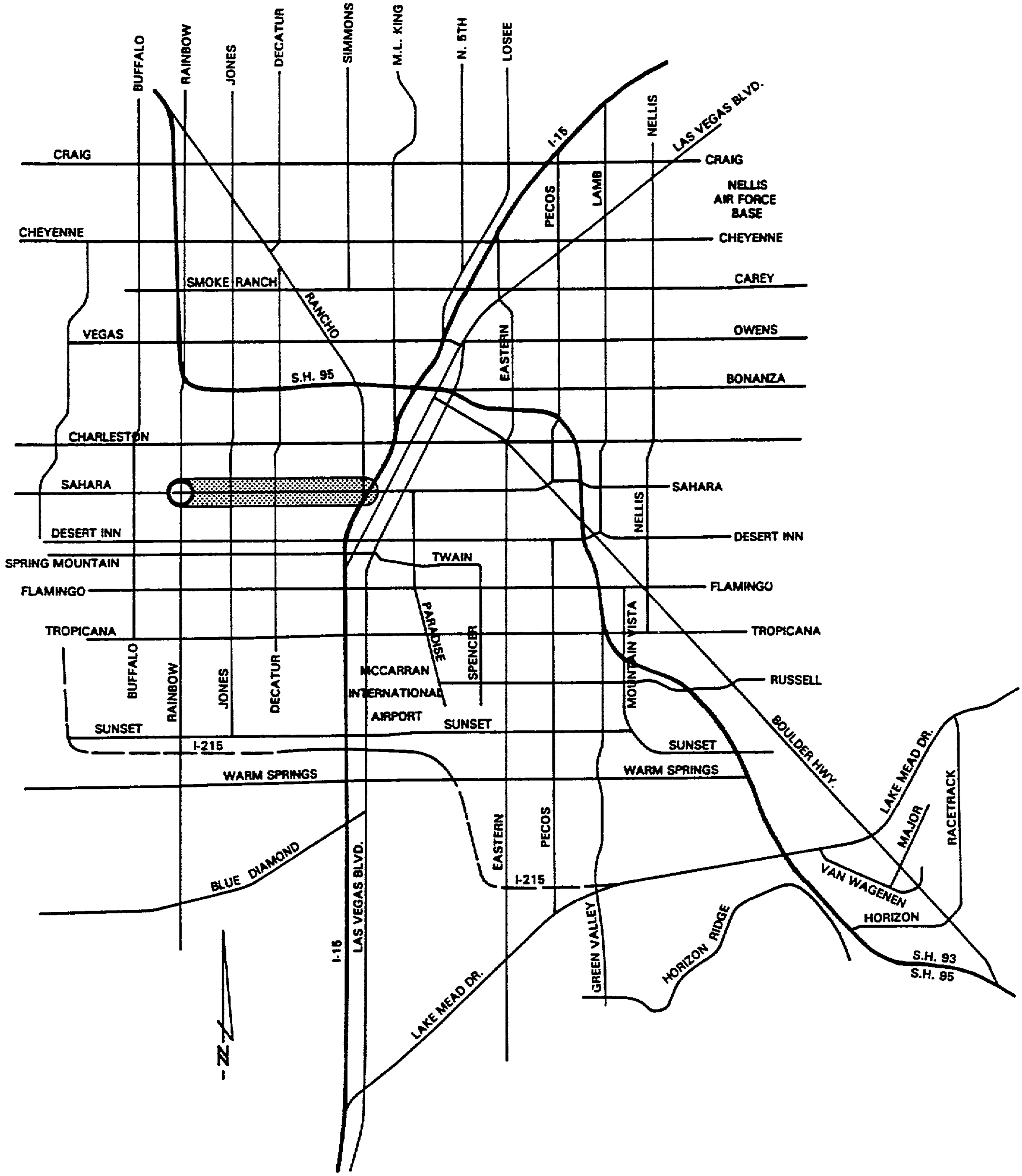
- The corridor must be easily accessible to the microwave backbone communications system.
- The arterial must be heavily congested.
- The cross streets of the arterial must range in functionality from a minor collector to a major arterial.
- The majority of the intersections along the arterial must be served by the existing twisted-pair copper wire network.
- The corridor must contain eight to fifteen signalized intersections along three to six miles of roadway.
- The arterial must include a diamond interchange.

This corridor is illustrated in **Figure 3.** Several communications, video imaging, and video surveillance systems were installed and evaluated at selected intersections. These locations are listed in **Table 4,** along with their corresponding intersection number, an approximate distance, proposed communications media type to the next westbound intersection, and any advanced technology proposed for deployment. Results from these evaluations provided important insight into installation procedures, operations, and maintenance of the various systems. This demonstration corridor can also be utilized to evaluate other technologies and / or integration with other systems.

COMMUNICATIONS SUBSYSTEMS

Microwave Backbone Communications

The video surveillance subsystem for LVACTS will create the greatest load on the communications subsystem. Other industries, such as cable television, have already pioneered the effective movement of video signals. CATV operators have used microwave radio to provide hub communications within their networks. These systems were designed to fit with the format of video on cable systems, which is very similar to conventional over-the-air broadcast television. TV channels cover the frequency spectrum from 54 MHz to 490 MHz, and channels are spaced in 6-MHz increments. Several companies manufacture



LEGEND

Microwave Hub Location

Demonstration Corridor

FIGURE 3

LVACTS DEMONSTRATION CORRIDOR

TABLE 4. DEMONSTRATION / EVALUATION CORRIDOR SUMMARY					
Intersection with Sahara	Intersection Number	Approximate Distance to Next WB Intersection (ft)	Proposed Communication Media to Next WB Intersection (type)	Proposed Video Surveillance Camera	Proposed Visual Image Detection System
IH 15 EBFR	162	300	Exist. Twisted Wire Pair	NO	NO
IH 15 WBFR	163	300	Exist. Twisted Wire Pair	NO	NO
Rancho	240	1400	Exist. Twisted Wire Pair	YES	NO
Teddy	304	1200	Exist. Twisted Wire Pair	NO	NO
Richfield	242	1100	Exist. Twisted Wire Pair	NO	NO
Spanish Oaks	287	1700	Exist. Twisted Wire Pair	NO	NO
Valley View	243	2600	Exist. Twisted Wire Pair	YES	NO
Arville	6	2700	Exist. Twisted Wire Pair	NO	NO
Decatur	110	2200	31 GHz Microwave	YES	YES
Lindell		2700	31 GHz Microwave	NO	NO
Jones	274	2300	31 GHz Microwave	NO	YES
Torrey Pines	408	2700	Exist. Twisted Wire Pair	YES	NO
Rainbow	22	End of Corridor	End of Corridor	YES	NO

microwave transmitters and receivers that use amplitude modulation to transport the entire CATV band in one shot. These products use two bands of the microwave spectrum: 13 G Hz and 18 G Hz. The lower band is reserved for cable television operators providing CATV services to the public at large and the upper band for private cable operators, such as wireless cable systems. The Las Vegas backbone system will utilize both the 13 and 18 GHz bands. Each of these bands will require path clearances and an FCC license.

In response to the increase in video standards that accompanies the switch to digital television, cable

operators have been systematically upgrading their networks to fiber-optic trunk systems. Consequently, portions of the microwave spectrum are becoming available as cable operators abandon them. While picture quality is a key issue with cable subscribers who use the video images for entertainment, it is not as critical for video surveillance in a traffic system. Most traffic system operators would be quite pleased to have video signals at the quality standard attained by typical cable televisions systems.

High frequency microwave, like all radio, is subject to atmospheric interference from time to time. The higher the frequency, the more pronounced the attenuation from obstacles in the path. Obstacles include the obvious blockages from buildings and from terra firma, as well as subtle interference from humidity and precipitation. In the case of Las Vegas, the average annual rainfall is less than seven inches, and microwave signals propagate more effectively there than in most places. Antennas for these frequencies can be as small as two feet in diameter, but most of the antennas in the Las Vegas system will be four or six feet in diameter, and will be installed atop 60,80, and 100-foot monopoles.

The advantage of borrowing technology from the cable television industry is that it is compatible with readily available and inexpensive components in the control center. For example, the Las Vegas system will not employ the typical video demodulators and large video matrix switcher that is common on most surveillance systems. Instead, the LVACTS traffic management center will be equipped with standard cable-ready video recorders and television monitors. This approach allows full flexibility using system components that can be purchased and repaired at consumer electronics retailers.

The Las Vegas backbone system does employ ring topology at five hub locations. Ring topology improves the reliability of the system by providing two paths for each video image to take from the place it enters the ring to the LVACTS Traffic Management Center. All video images are transmitted both clockwise and counterclockwise around the ring. The total 18 GHz band of 72 video channels is divided into two sub-bands, and separated from each other by leaving the eight channels in the center of the band unused. This approach allows 32 video channels on the backbone, with four reserved for data. Sixteen T-l data channels will be implemented on the four video channels used for data to provide high-speed communications between the Traffic Management Center and the computers at each hub.

The use of ring topology for broadband AM microwave is a first in the traffic industry and in the microwave industry. Despite the innovative application, however, all the equipment in the system is readily available off-the-shelf. The backbone system provides communications to the hubs, but much work is still to be done to get data from the signal controllers and images from the cameras to the hubs.

Local Communications

The communications infrastructure is the most expensive component in most new signal systems. The cost of placing physical infrastructure in the ground has risen dramatically over the last decade, and most systems now being installed are being designed around some compromises. System designers of past years relied on one technology for most signal system communications-twisted-pair copper wire. The approach was a privatechannel architecture, where each individual controller has a private channel, either physical or multiplexed, that allows direct communication with the central computer. These systems typically allow four or eight local controllers on each physical pair. Some newer systems employ a shared-channel approach, where groups of local controllers all speak on the same channel, taking turns by including the controller's address in each message. These systems typically allow up to 32 local controllers to share a physical channel. Most of these systems, however, have still been based on twisted-pair copper.

LVACTS is fortunate to already have in-place an extensive conduit and twisted-pair cable network. Cable sizes range from six-pair to one hundred-pair #22 AWG cable. Unfortunately, the conduit in this network is unreliable in terms of integrity and available space. Without a comprehensive inspection of conduit runs new cable could not be installed with any degree of certainty. The conduit network also did not keep pace with the expansion of the signalized intersections in the Valley. This lack of expansion is one of the reasons that over sixty-five signals are not tied into the system. Considering the reliability of existing conduit, the local agencies mandate of "no new conduit", and the added communications capacity of video surveillance, other communications media were identified to move data and video from the intersections to the microwave backbone hub sites. These communications alternatives are detailed in the following sections. The LVACTS local communications network can be found in Appendix C.

Twisted Pair Cable

Traditionally, twisted-pair copper would not be thought of as sufficient for communicating video images for any distance. One should note that copper wire is capable of transmitting very large bandwidth. For example, many products now carry focal area network connections over twisted pairs. The LAN data rate is 10 megabits per second, which is very high. The distance, however is limited to a few dozen feet. At long distances, such bandwidth cannot be accommodated, and designers are faced with the decision to employ specialized analog transmission equipment to compress the analog signal into the capability of the wire, or to digitize the video signal and compress the signal digitally. Many systems today have employed the latter approach. While this approach is certainly valid, it is also costly, and may cause unacceptable degradation of the video image. Most digitally compressed video signals are extremely clear, because noise cannot invade the digital signal. They usually limit the interval at which moving objects can be displayed. For video conferencing, which is a popular application of compressed digital video, the slowing of the image update frequency is no problem. For traffic surveillance, however, many compression schemes interfere with the effectiveness of the image because of the jerky appearance of moving vehicles.

Technology continues to improve the quality of digitally compressed video images. This technology is contained in devices known as codecs, which convert the analog video image into compressed digital signals. High-quality codecs are expensive, and even more so when designed to withstand the extended temperatures required by traffic equipment.

To avoid the cost and complexity of compressing codecs, and to maintain smooth video, the designers of the new Las Vegas system decided to avoid digitizing the video image and to employ innovative technologies to transmit analog video signals. This decision was consistent with the backbone communications system, which transmits only analog video.

Two technologies were identified that can provide analog video transmission over reasonable distances relatively cheaply. One is a video transmitter that transmits a full 10-MHz video signal over a single twisted pair of copper wire. The range of the equipment is about 3500 feet, and can be repeated up to five times for a total range of three to four miles. This equipment was evaluated by moving two video signals side-by-side over existing twisted-pair copper along the Sahara Avenue demonstration corridor. The total distance of the test was about a mile, and the two video images maintained very high quality. During the test, the existing UTCS communications were uninterrupted over pairs in the same cable bundle used for video. Some repair of the existing cable was required to correct faults that would degrade the image. When employing this technology on existing wire, rehabilitation of the wire will usually be required. The equipment is the Hardwire Video System, manufactured by Mil-Lektron. The cost of a link of Mil-Lektron equipment is about $1,500 per end and repeater, but not including the wire. The Las Vegas project will use this technology to move approximately eighty miles of video signals on the existing cable plant.

Fiber Optic Cable

For a few isolated links, the system designers have had to resort to fiber optic cable. Two primary links were unsuitable for microwave. One link connects the LVACTS Traffic Management Center with the Clark County Jurisdictional Management Center. Because this location is in the downtown area, microwave line of sight was not available because of intervening buildings. In this case, fiber optic cable will be installed in existing conduit, which will require rehabilitation of the pull boxes along the path, and in new conduit being installed in a street paving project covering much of the distance. The other location is the connection between the North Las Vegas JMC and one of the backbone hubs. This hub has already maximized the number of antennas allowed at one location. Therefore, this JMC will be connected with fiber optic cable installed in new conduit.

To maintain the channel spacings, and to provide complete flexibility at the remote management centers, the system designers have again borrowed technology from the cable television industry to move the entire band as a wideband signal. The data connection to these locations will be an Ethernet bridge over separate fibers.

31 GHz Microwave Communications

For areas not reached by cable, system designers will employ 31-GHz microwave radios. These radios are housed in standard single-section traffic signal heads, and can be readily mounted on signal poles. The total range of these devices is about a mile, though in the dry Las Vegas air the range is potentially several miles. As with the Mil-Lektron equipment, the signal can be repeated up to five times. A key advantage to the 31-GHz band is that it is not subject to frequency coordination by the Federal Communication Commission. Because 31 GHz radio signals propagate poorly, many systems can coexist without interference, and the FCC has not placed controls on the band. These microwave radios are configured to provide three different bandwidths: regular data (64,000 bits per second), T-1 (1.544 megabits per second), and analog video. Up to four channels can be transmitted with side-by- side antennas on six different frequencies in the 3 1-G Hz band. In Las Vegas, the system designers implemented two 3 1 -G Hz systems in a sideby-side evaluation along the Sahara demonstration corridor covering a distance of one mile. The equipment in the test was manufactured by Sierra Digital Communications and supplied by Sunnyvale General Devices and Instruments, Inc., and provided near-broadcast quality video images. In single units, a complete video link with this equipment is about $25,000. The video equipment provides one video and one data connection in the inbound direction, and another data connection in the outbound direction.

The evaluation focused on two objectives. The first objective was to determine the quality of a video image which has been transmitted over the 31 GHz microwave. The second was to determine if multiple signals could be transmitted along the same line of sight over two closely spaced antennas.

Both objectives were completely successful. A single transmitted image from Rainbow was received at Jones with excellent image quality. Transmitting the second image along the adjacent path caused no image degradation. It should be noted that there is a maximum of four video signals which may be transmitted on adjacent paths over the same line of sight. Finally, the loop was completed by successfully sending an image from Rainbow to Jones and back to Rainbow with excellent image quality.

Due to the positive evaluation results, the 31 GHz microwave technology has been incorporated into the overall system design. Approximately fifty such wireless video communications links have been designed into this system upgrade.

900 MHz Real-Time Radio

For those locations served by neither twisted-pair copper nor microwave, the systems designer needed a lower cost alternative to provide data-only communications to the local intersection controller. After exploring several alternatives, the OMC decided to employ a dedicated-channel multiple-access data radio system. Several manufacturers provide systems that provide point-to-multipoint communications between a central station and many local controllers. The System Designer have identified six repeater stations in the Las Vegas Valley to provide dedicated multiple-access data radio to about 175 locations. The repeaters will share the towers installed for the microwave backbone system. A frequency pair in the 960 MHz band is required for communications sufficient to provide once-per-second polling to a number of intersections.

800 MHz

Many agencies in the Las Vegas Valley currently use an 800 MHz voice trunking radio communication system. With this in mind, this system would be a logical communications alternative for evaluation. In evaluating the existing 800 MHz system, specific characteristics of this system and general characteristics of trunking systems in this band were looked into. The 800 MHz system is designed for voice communications, and allows the mixing of some data into the traffic stream. The system operates on dedicated frequencies, and is generally omnidirectional. The purpose of the system is to allow multiple applications in the same trunking system without mutual interference, primarily in voice radio applications where some data encoding is also required, such as emergency services applications. The system is not designed for high-repetition polling or real-time data movement from large numbers of remote units.

The existing system is not configured for full duplex operation. However, the requirement for simultaneous two-way communications is possible. The primary limitation of the existing trunking system for hub-to-local communications is the time required to gain access to the channel. Assuming that the channel is open, this acquisition time is 250 to 500 milliseconds, or a quarter to half second. Even with self polling, the time required for one intersection to cease communications and the next to begin is far longer than with other technologies. The system is designed for messages that take several seconds, so the overhead of acquiring the channel is not significant. This limitation precludes the use of this medium for real-time monitoring of intersections, especially in the number required for future build-out of the system. This voice trunking system can provide an adequate means of occasionally communicating with remote devices in the field which can be utilized in the future by those agencies requesting to do so at remote sites.

CONTROL CENTER SUBSYSTEMS

Traffic Management Center

The primary design philosophies for the Traffic Management Center (TMC) are to provide a user-friendly system interface and to maximize the space requirements in the existing facility. This was especially important in light of the two additional LVACTS staff members.

In considering a plan for the video surveillance and display equipment at the TMC, other control centers were evaluated from around the country. The TMC and each of the JMC's are directly connected to the backbone, and have access to surveillance video. Dial-up terminals will not have access to surveillance video.

The TMC, shown in **Figure** 4, is a self-contained building containing a large room for system operations, office space, a conference room, restroom facilities, and work space for electronic component repairs. Large monitors have been recommended for this environment. The existing hard-wired map display will be replaced with an array of four 50-inch high quality rear projection video monito rs and six 36" internally illuminated video monitors. For workstation data displays, 21" high resolution (1024 x 1280) displays for all computers in the control room will be utilized. These will also be capable of displaying video surveillance images in a window.

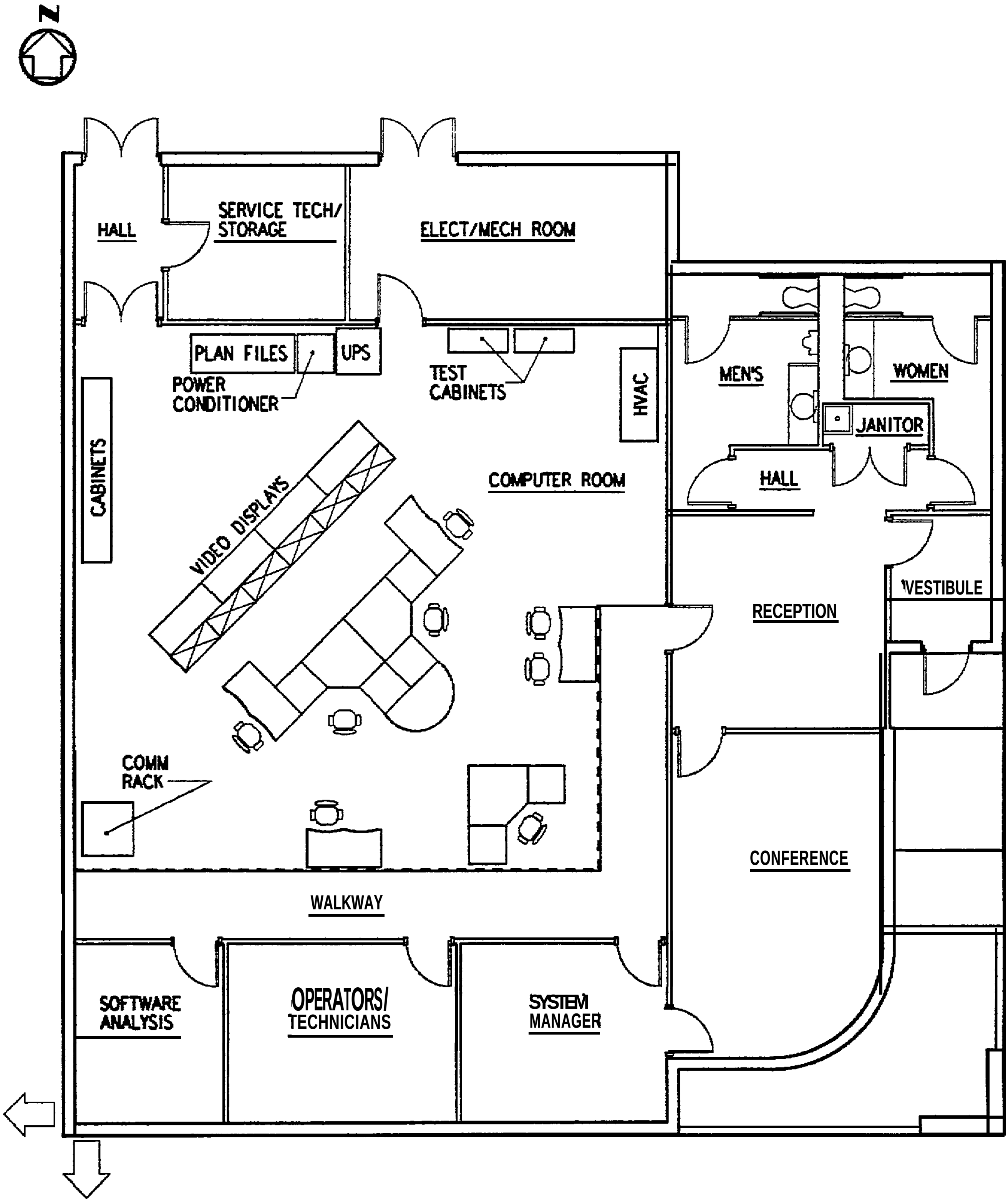
Jurisdictional Management Centers

The City of Henderson, City of North Las Vegas, and Clark County will operate their own JMC. The City of Las Vegas has decided, with OMC concurrence, to utilize LVACTS staff for daily system operations and maintenance activities. Each of the JMC's will be capable of accessing all video surveillance cameras and local controllers within their jurisdiction and the majority of cameras and controllers within the system. Each of the local agencies requiring a Jurisdictional Management Center (JMC) have provided built-out office space at their facilities. Each JMC will be provided a communications link to the microwave backbone system, a high processor computer with a 21" monitor, computer furniture, and an array of four 36" monitors. The monitor bank will be about seven feet high and five feet wide. The data displays at the workstations will be similar to the TMC. Full-time video conferencing can be provided to each of the JMC's and TMC, and could be available as a window on the 2 1" monitors.

VIDEO SURVEILLANCE SUBSYSTEM

In order to effectively operate an advanced traffic signal system, the operator must have knowledge of the day-to day traffic characteristics within the network. He must also have the ability to respond to changes from routine patterns. Historically, the operator has been tasked with driving to a given area to visually observe the traffic characteristics prior to making operational changes, then relying on a floating car technique to observe the effect of his changes. This practice has traditionally required a great deal of time and effort to provide safe, effective, and efficient traffic operations. Unfortunately, this practice is often limited because of staffing restraints. Today, surveillance technology has improved to the point where system operators can use traffic data collection stations and video cameras to monitor changing traffic conditions greatly multiplying the staffs effectiveness by eliminating travel time.

The cornerstone of the new system will be the ability of the system operators to remotely view traffic operations at many critical locations effectively. Transporting these video images back to the system operators is difficult because of the bandwidth requirements of full-motion video. Because LVACTS is a multi-jurisdictional system, the video surveillance system must serve several traffic management centers. The system will feed images from 47 video surveillance cameras distributed around the area to 28 display monitors at the various traffic management centers. This critical surveillance capability will provide the means to maintain the operation of the traffic signals at optimum levels and therefore realize the full potential of this large public investment.



DIRECTION OF FUTURE BUILDING EXPANSION(WHEN REQUIRED)

FIGURE 4

FLOOR PLAN

TRAFFIC MANAGEMENT CENTER MODIFICATIONS
LAS VEGAS, NEVADA

BARTON-ASCHMAN
ASSOCIATES, INC.

LOUIS BERGER
& ASSOCIATES. INC.
LAS VEGAS, NEVADA

Several camera manufacturers and their various technologies were evaluated along the demonstration corridor. This study revealed that numerous problems can occur during the installation of camera equipment and precautions must be taken to prevent unnecessary field changes and additional work orders during the construction process. Therefore, each agency provided input on the locations within their jurisdiction where video surveillance equipment was to be installed, such as providing an assessment of conduit availability, field of view restrictions, microwave communications antenna restrictions, and any apparent obstacles which might hinder the installation of video or communications equipment. The effort expended during this planning phase should greatly reduce the problems, and the costs associated with correcting those problems encountered during construction.

Approximately 42 video surveillance cameras initially will be installed throughout the Las Vegas Valley. LVACTS will be able to view an additional five cameras being constructed as part of the Desert Inn Super Arterial project. All proposed camera locations are shown in **Appendix D.** Several dozen more cameras could easily be added to the system as the need is defined.

LOCAL CONTROL SUBSYSTEM

The local controller, which will conform to the Caltrans 2070 specification with NEMA type connections, will have computing power much greater than the latest of the current controllers. More power does not, however, suggest more difficulty of use. In fact, a more powerful controller can be programmed to make it easier to use.

Coordination timing will be performed locally, and will not be affected by the intersection's communications status. If any component of the system upstream from the local controller goes down, the local will continue as it was without interruption.

Hardware

The Caltrans 2070 specification is currently being developed by a committee consisting of the California DOT, the City of Los Angeles, the FHWA, and others. The 2070 is not related to the current 170 controller, except that it is intended to fit in a 170 cabinet (as well as a typical NEMA cabinet). The controller will consist of a VMEbus passive-backplane computer, plus the necessary input, output, and power supply hardware. The VMEbus is an advancement of the VersaBus designed by Motorola some years ago, and is standardized by the IEEE and widely used in industrial applications. So far, Caltrans has determined that the 2070 will use a 68020 microprocessor and will run the OS-9 operating system. The anticipated quantity cost, including modem and operating system software, is less than $3000, and it will replace the existing controller and coordinator. The 2070 is the next step in the ATC (Advanced Transportation Controller) development process, and Caltrans anticipates having a purchase specification ready by fall 1995.

At most locations, the existing cabinet will be adequate for the new control equipment. The new controllers will be designed to work within the standard NEMA framework, which implies 8-phase dual-ring operation with 12 load switches. Those few remaining controllers with four-phase cabinets are generally two-phase operation, and the 6 load switches will be adequate. The new controller will fit in a box 19 inches wide (standard rack), 7 inches high, and about 12 inches deep. This is quite a bit smaller than NEMA allowable dimensions.

With the exception of three cabinet changeouts associated with the video surveillance system, no cabinets were identified for replacement. This represented a very large cost saving compared to typical signal system installations.

Software

Traffic operations software for the 2070 controller is currently being developed by the design team. Functional requirements of this software were developed to exceed the design goals of increasing operations reliability, reducing operations and maintenance costs, and overcoming virtually all (major and minor) operational limitations of the current system. The major functions to be supported by the local microcomputer software are listed below:

- Provide for fullytraffic actuated operations for a minimum of two logical phases and a maximum of sixteen logical phases.
- Provide for the concurrent timing of up to 32 logical phases.
- Provide the capability to control up to 32 signal load switches.
- Provide for the coordinated operation of local intersection controllers through imposing one of up to 32 locally stored timing plans to be selected on a time-of-day, day-of-week, week-of-year basis. Phase sequencing configurations shall be selectable via timing plan.
- Provide for transition between coordinated timing plans as well as for transition between fully traffic actuated and coordinated modes of operation.
- Provide a 52 week clock with built-in daylight savings and leap year corrections.
- Provide a time clock capable of implementing up to 192 day program events, 10 week programs, 26 yearly week program changes and 16 exception days.
- Provide upload and download of the data base from the central and / or JMC computers.
- Support the man-machine interface consisting of a 4 row 40 column LCD display and dual 16 keypad.
- Provide for the collection, storage, and upload of volume and speed data from up to sixteen system detectors over a 36-hour period at five minute intervals.
- Provide detailed failure analysis monitoring and logging.
- Provide detailed operation monitoring and logging of user changes in signal timing/programming.
- Provide security against unauthorized editing of data base contents.
- Support fully user programmable inputs and outputs.
- Permit separate timing and release of the primary coordinated phases in any ring so that cycle time no longer needs to be allocated to the leading and lagging left-turn phases as if they were conflicting movements.
- Permit variable lead-lag (and/or twice per cycle) left-turn servicing as a function of timing plan in effect.
- Permit long cross street pedestrian services, even when the basic split time allocated for that movement is less than the pedestrian crossing time.
- Support permissive side street phase activation timing so that coordinated phase extension is actuated with or without rest-in-walk operation (i.e., non-CNA coordination).
- Support conflicting coordinated phases at intersections where two progressions cross so that the slack time generated by the local actuated operation may be allocated between the two main streets.
- Provide for minor phase servicingtwice per cycle in a long permissive window in order to reduce objectionable high delays to side street traffic.
- Automatically record number of side street phase actuations and automatically compute and log the average split of each phase over the period during which the particular timing plan is in effect.

These functional requirements are detailed in the LVACTS Local Controller Software Design Requirements Document, dated June 9,1994.

DETECTION SUBSYSTEM

Vehicle detection can be split into categories of full /semi-actuated control at the signalized intersection or system control /traffic counts. Both are important to the efficient operation of the system. Although an extensive inventory and operations evaluation of existing local detectors was conducted, additional local detectors for signalized intersections were not included in this system upgrade. Malfunctioning detectors were identified and reported to the respective agencies for repair.

As part of the LVACTS upgrade, system detector locations were identified for system control and traffic count collection. Five special event generators were identified within the Las Vegas Valley which required system detection. The special event facilities included the Thomas and Mack Center, the Silver Bowl Stadium, the Las Vegas Convention Center, the Cashman Field Center, and the Southern Nevada Community College. Traffic count locations were identified by NDOT with input by the member agencies.

Visual image processing and inductance loops were two vehicle detection systems considered for system detector use. Vehicular detection systems using visual image processing are relatively new to the traffic signal industry. These systems offer the ability to recognize a moving object, accumulate statistics regarding the object's movement and notify control systems of the object's presence. A technical evaluation conducted within the demonstration corridor found this technology a viable means of vehicle detection. However, due to the capital outlay for these system types and the fact that system detectors had been located away from any existing pole structures, visual image processing was not recommended because of the low cost-effectiveness. This is a rapidly advancing field, however, and video-based detection may soon be chosen as the defacto method.

The more traditional detection type utilized for system detection was inductive loop detectors. The advantages of this alternative are capital costs, hardware familiarity, installation ease, and maintenance costs. Approximately 260 system inductiveloop detectors at 100 locations have been designed for LVACTS. The locations of the system detectors are highlighted in **Appendix E.**

PROJECT PHASING /SCHEDULING

As part of the Construction Administration contract, Barton-Aschman will prepare a formal construction schedule. *Microsoft Project,* a project and construction planning guide, will be utilized for this effort. Remaining construction will be administered either through a contractor or an agency force account. All system components, except the local controllers, will be constructed by a contractor. The local controllers will be purchased by NDOT and installed by the local agencies under force account work.

DESIGN REVIEW

Extensive reviews by member agencies and interested parties have been conducted throughout all phases of the system upgrade. Technical memorandums and design documents addressing equipment evaluations, design concepts, and detailed designs, specifications, and estimates have been gradually given to the OMC and interested parties for their review and comments. All comments from these reviews have been addressed in the final construction documents.

IV. PROCUREMENT METHODS

METHOD

Several procurement methods have been employed for various components of the Las Vegas signal system upgrade project. Traditional procurement methods including sole-source, engineer / contractor, systems manager, and design-build have been used on many other signal system upgrades. The latter three methods have been incorporated into the procurement process for the Las Vegas system. The consultant team headed by Barton-Aschman Associates, inc. serves as the project manager. Project manager responsibilities include design, preparation of plans, specifications, and estimates, software development, timing plan preparation, system testing and integration, as well as providing construction administration expertise. NDOT, however, will be administering all construction contracts and conducting all inspections.

Three separate construction contracts will be advertised as part of the upgrade. The first contract was the microwave backbone communications subsystem. The project manager prepared functional designs and specifications for this subsystem. Since the final design hinged on the selected equipment vendors and their particular equipment, the detailed designs were relegated to the contractor. This design / build approach is standard for microwave communication systems. The next construction contract was prepared for the installation of the local controllers. NDOT will purchase the controller hardware through their bidding process. Doing this allows two advantages: 1) NDOT will have only one entity to work with in resolving problems with these innovative controllers, should problems arise, and 2) NDOT will not have to pay a contractor's handling costs and markup on the controller purchase. Installation will be conducted by the local agencies under a force account agreement with NDOT. The last bid package includes construction of all local communications, video surveillance, system detection, TMC building modifications, and TMC / JMC computer hardware.

SCHEDULE

The LVACTS upgrade has been developed in several phases. The initial two phases, the "Preliminary Feasibility Study" and the "Conceptual Design Study", were completed in 1992 and 1993, respectively. These phases laid the groundwork for the system design and implementation. Final design for all system components is now complete. System construction, software development, signal timing development, timing and system training, and acceptance testing are tasks that will be completed in the Fall of 1996. Figure 5 illustrates the remaining project schedule.

FUNDING

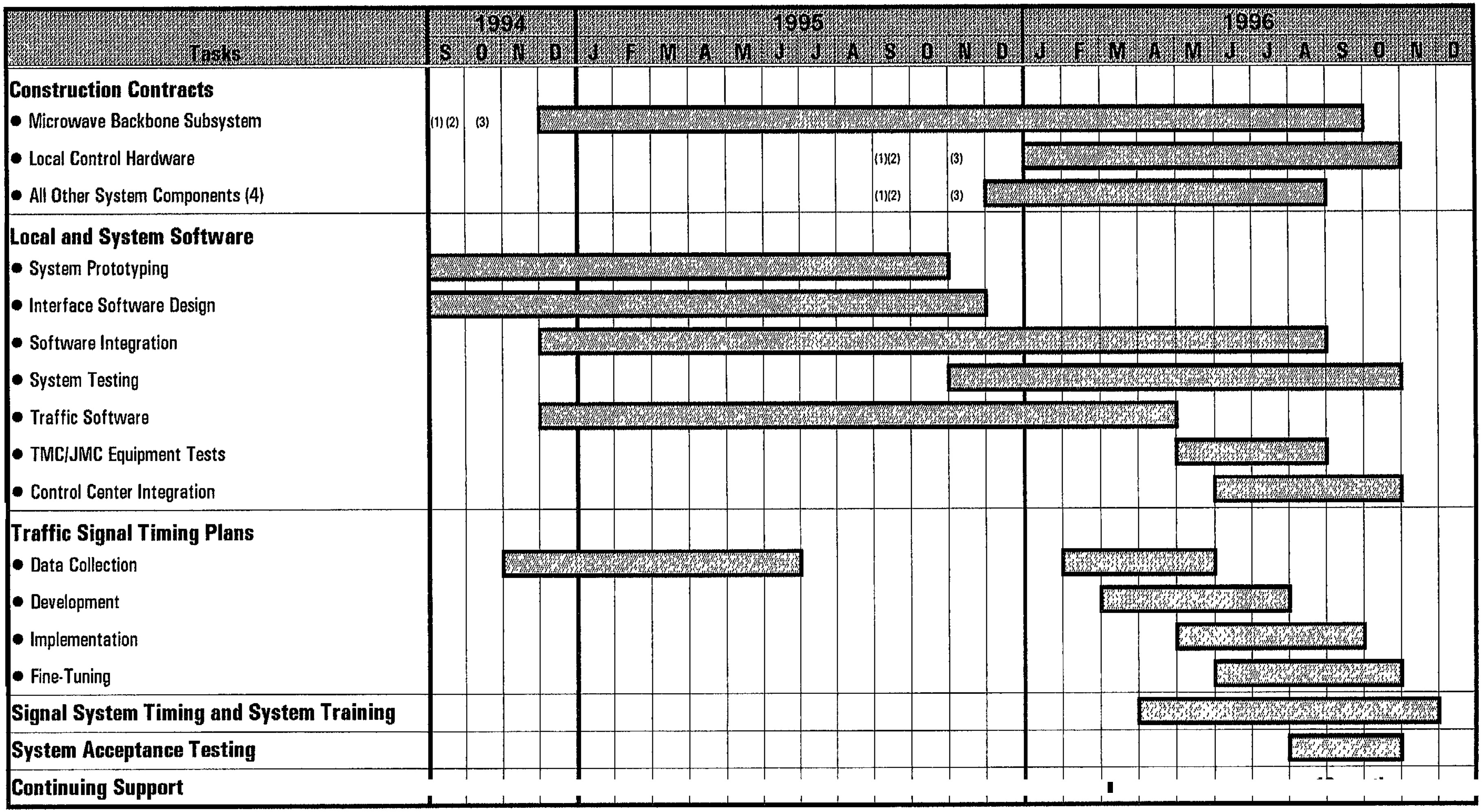
The LVACTS Upgrade project possesses the distinction of being the number one priority project on the Nevada Statewide Transportation Improvement Program (STIP). With this ranking, funding has not been a major issue. However, a major issue related to system funding has surfaced within the last few months. The model used to determine airquality in the valley was recalibrated when new assumptions were input. The recalibrated model showed the potential for airquality exceedances over the next year. Under the Clean Air Act Amendment of 1990, the Environmental Protection Agency (EPA) can impose strict sanctions and/or withhold federal funding from the State of Nevada if air quality non-compliance becomes an issue. Therefore, additional state funding has been identified to compensate for any shortfall in CMAQ funding. Three sources of funding have been utilized for the design, construction, and implementation of the system. These funding sources include NDOT OAV funds, NDOT STP funds, and FHWA CMAQ funds. The sum total of the system design and construction budget has been estimated at **$12,461,811.** This preliminary estimate is summarized in **Table 5.**

TABLE 5. PRELIMINARY ESTIMATE FOR THE LVACTS UPGRADE

Item Description	Engineering Cost		Construction Cost (1)
	PE	CE	
A. Phase 3 Design	$1,037,271	---	---
B. Backbone Communications	---	---	$3,459,511
C. Demonstration Corridor Equipment	---	---	$230,000
D. Phase 4 - Implementation	$585,423	$475,037	---
E. Henderson Extension	$258,937	$94,111	---
F. NDOT Construction Administration	---	$193,261	---
G. Barton-Aschman construction Administration	---	$275,000	---
H. Video-Surveillance, Local Communications, System Detectors, and TMC/JMC Upgrades	---	---	$3,586,230
I. System Computer Hardware	---	---	$320,330
J. Local Control Installation	---	---	$154,500
K. Local Control Hardware	---	---	$1,792,200
SUBTOTALS	$1,881,631	$1,037,409	$9,542,771
GRAND TOTAL			$12,461,811

(1) Construction costs include a three percent contingency.

FIGURE 5. LVACTS UPGRADE SCHEDULE



(1) Final Design Complete

(2) Advertisement

(3) Bid Opening

(4) This contract includes all local communications subsystems, vehicle detection subsystems, TMC/JMCs, and video surveillance subsystems.

V. CONSTRUCTION MANAGEMENT PROCEDURES

CONSTRUCTION ADMINISTRATION

All components of the LVACTS upgrade will be constructed using standard Nevada Department of Transportation (NDOT) construction administration techniques. The core management and inspection team, supplied by NDOT, will be supplemented with the technical and construction expertise of the design consultant. NDOT will remain the focal point for all vendor and contractor questions / requests.

The design consultant will provide one on-site employee with both technical and construction experience in traffic signal systems. This individual will provide observation and review of construction activities performed by the contractor, including the furnished materials and workmanship. This individual will also prepare weekly status reports, recommend and prepare change orders, review progress schedules, shop drawings, and samples, as well as provide technical guidance to NDOT.

Day-today construction activities will be inspected by NDOT personnel. NDOT will also be required to check construction techniques and sequences, as well as provide for job-site safety. NDOT personnel will present monthly project progress reports to the OMC.

SYSTEM INSTALLATION

System installation will be conducted by a contractor(s) and through an agency force account. All system components except one will be constructed by a contractor. Two construction contracts have been prepared for the system upgrade. The first contract includes construction of the microwave communications backbone system. This contract has already been awarded to Fischbach and Moore. The second contract will include the local communications subsystem, the video surveillance subsystem, the TMC / JMC's, and the vehicle detection subsystem.

The local controller subsystem will be installed through a local agency force account. Several factors enter into this decision, including reduced cost (no mark-up from a contractor), implementation time, scheduling, quality assurance, and technical assistance from LVACTS staff. All of these factors are advantages to performing the work with agency forces. Another advantage is that the technicians have an opportunity to work with the hardware and software of the new system directly. This work will allow them to become comfortable with the new system as it is being installed, and is much more effective than any amount of training. Even if this element were contracted, the local agencies' technicians would still be called on for oversight and inspection, however, the use of the force account method will eliminate the cost of the contractor.

VI. SYSTEM START-UP PLAN

The key to a successful system start-up lies in the comprehensiveness and quality of hardware and software component testing conducted prior to start-up.

ACCEPTANCE TESTS

Significant effort has gone into preparing detailed specifications and testing procedures to assure a smooth start-up transition. Component testing occurs during several stages of construction such that problems are identified and corrected early on, rather than to trying to discover and resolve old problems toward the end. Four basic categories of testing have been identified in detail for the Las Vegas Signal System Upgrade. These testing categories are as follows:

- **Pre-Installation Evaluations/Test**- an extensive evaluation of many system components has already occurred or is still ongoing. Prior evaluations include various communications media, computer hardware, video surveillance, and off-theshelf software packages. The evaluation of central and local software is an ongoing process. Prototypes of these software packages are sent to LVACTS for review on a monthly basis. On several occasions the LVACTS system manager has travelled to Houston to witness the development progress of the software and provided value input to the continuing evolution of the software. Some hardware components, such as the local controller, and others as identified in the specifications, will have extensive preinstallation testing conducted.
- **Equipment Submittals**-catalog cut sheets, shop drawings, and equipment list will be reviewed for adherence to specifications and standard detail drawings.
- **Component Tests** - after installation each component, including the backbone communication subsystem, the local communication subsystem, the detection subsystem, the video surveillance subsystem, and the local control subsystem will be extensively evaluated as per the specifications. Each component will be tested on an individual basis and in concert with other subsystem components. In general, each system component must operate for 60 consecutive days without failures of any type. In the event of a failure, the contractor will correct the problem and the 60 day test will start anew.
- **System Acceptance** Test-the integrated components of the construction project will be tested by the consultant team members to determine reliability and performance measures under actual traffic conditions of the system level. All software, firmware, user interfaces, and hardware will be thoroughly tested. More detailed information about system acceptance testing is found in the following section.

This section outlines the procedures and methods for conducting acceptance tests on the upgraded LVACTS control system. Tests are proposed to be made in the following categories:

- Communications Subsystem
- Controller Subsystem
- Data Base Management Subsystem
- Event Management System and Logging
- Video Surveillance Subsystem
- Display and Control Subsystem

The procedures to be followed in conducting each test are outlined in the following sections.

COMMUNICATIONS SUBSYSTEM

Communications Subsystem Integrity Testing (Field)

- Connect a signal generator and a bit error rate tester to the communications line at the TMC.Connect a modem to a wire pair at a remote controller location. Place this modem in a loopback test mode.
- Turn on the signal generator and use the Bit Error Rate tester to measure any difference in the outgoing and incoming message streams. Conduct the test for a period of at least an hour. Insure the bit error rate is within tolerance (at least 1 x 10).

Communication Subsystem Testing (TMC/IMC)

- Use the same type equipment as above except place a loopback device at the JMC. As before, run the tests for each JMC for a period of at least an hour. Insure bit error rates are within tolerance.

Communication Subsystem Testing (TMC to Portable Laptop)

- Use the same type equipment as above except place the loopback device in a remote vehicle fitted with cellular communications equipment. Run the test for a period of at least one hour. Insure the bit error rate is within tolerance.

CONTROLLER SUBSYSTEM

- Load the controller database with at least three timing plans and a Time-of-Day schedule which calls for each of the plans throughout the course of the day.
- Run the controller and verify that the timing plan changes occur when scheduled.
- Make sure timing plan transitions occur in accordance with the user input transition schemes.
- Place calls on each actuated phase and insure the actuated phases are serviced in the correct sequence. Insure the controller operation adheres to the preprogrammed cycle length, splits, and offsets.
- Program one or more pedestrian phases which cause the controller to go out of synchronization when the pedestrian phases are serviced. Verify that the controller comes back into synchronization within the user prescribed time.
- Select a controller equipped with a preempt device. Activate the device and verify the controller goes to preempt in the proper sequence. Verify the controller goes back to synchronization through the proper sequence when the preempt is removed.
- Verify that the system detectors are providing reliable output to the controller.

DATABASE MANAGEMENT SUBSYSTEM

- Input a typical data base into the central system server. Also, input a prioritized hierarchy of user passwords. Verify that users not given full access rights to the data base are prevented from making changes to sensitive data.
- Using a password with full access rights, download an entire data base to a local intersection controller. Verify that the checksums received by the local controller match those transmitted by the central server and that all data are stored locally in the correct address locations.
- Reverse the procedure by uploading an entire local controller data base to the central server.

Insure all checksums received by the central server are identical with those generated by the local controller. Verify that all uploaded data is placed in the correct address locations.

- From a remote lap top computer device, transmit changes to a local controller data base to the central server. Verify the central server downloads the user specified changes to the selected controller data base.

EVENT MANAGEMENT SYSTEM LOGGING

- Place a local controller in the flash mode. Verify the central server logs the correct date and time that the controller went into flash.
- Place a local controller in the preempt mode. Verify the central server logs the correct date and time that the controller went into preempt.
- Disconnect a local controller from the communications line. Verify the central server records the correct date and time that the controller failed.
- Activate all of the remote sensing relays individually. Verify that the sensor was tripped.

VIDEO SURVEILLANCE SUBSYSTEM

- From the TMC and each of the JMCs remotely control all camera functions (pan-tilt, lens, power).
- Measure video signal level at the modulator or fiber-optic transmitter with an oscilloscope.
- Measure the noise in the video signal.
- Randomly select at least three installed cameras to verify camera enclosure pressurization.
- Display each camera on all video monitors in the TMC and JMCs to verify proper video switch operation.
- Operate all video recorders to verify recording and play-back operation in conjunction with the video system.
- For nighttime operations, display each camera and operate all remote control functions while observing both the brightest and darkest scenes available from each camera location.
- Activate the entire video system and conduct an extended test for thirty (30) calendar days. If a major component of the video system remains inoperable for over five (5) working days, the entire extended system test shall restart after the problem is eliminated by the contractor.

DISPLAY AND CONTROL SUBSYSTEM

- Activate the Intersection Graphics display at the central site for a given local controller. Place an observer in the field at the controller location. Verify the Intersection Graphics display accurately tracks the colors displayed at the local intersection.
- Activate the Valley Area Operations Status Display at the central location. Verify the display accurately reflects the following conditions at a given local intersection:
    - Comm Fail
    - Flash
    - Preempt
- From the central location, manually activate a given timing plan for a zone of controllers. Verify the zone properly transitions to the manually commanded pattern and that the pattern change is properly logged at the central location.

DOCUMENTATION

Detailed documentation is the foundation that insures long-term success of a systems operation. This documentation includes, but is not limited to, the following.

- Operations and maintenance manuals
- Wiring diagrams and electrical schematics
- As-built plans
- System reference, operators, and database manuals
- Software documentation

operations and maintenance documentation requirements for system hardware has been outlined in the specifications. Local controller software and system software is currently being developed by the consultant team.

Fifteen (15) complete sets of the operation and maintenance manuals shall be provided. The manuals shall include the following:

1. Complete and accurate schematic diagrams.
2. Complete installation procedures.
3. Complete performance specifications (functional, electrical, mechanical and environmental) on the unit.
4. Complete parts list including names of vendors for parts not identified by universal part numbers such as JEDEC, RETMA or EIA.
5. Pictorial of component layout on circuit board.
6. Complete maintenance and trouble-shooting procedures.
7. Complete stage-by-stage explanation of circuit theory and operation.

Schematics shall be updated at the end of the project to show "as-built" conditions.

SYSTEM TRANSITION

The system architecture developed for LVACTS allows orderly and nondisruptive installation. Before replacement of local controllers or removal of the old system, the new central system will be installed along with the hubs and broad-band communications links.

During implementation, the outermost signal on a cable branch will be replaced with a new controller. The new controller will run in time-based coordination for the time being. The installation crew will work inward from this controller back to the hub. At each intersection, they will disconnect and remove the old controller and interface unit, and install a new controller (usually in the same cabinet). The new controllers will be coordinated by time base, and the remaining old controllers will still be working on the old system. Once a branch has been completely replaced, it will be disconnected from the old system and then connected to the hub and new controllers. Implementation will proceed branch by branch from the edges of the hub regions in until all the controllers are replaced. At that time, the old central system can be removed.

New traffic signal timing plans will be prepared by Barton-Aschman along selected arterials. Approximately 260 intersections will be retiming in this task. Programming for the new controllers will be performed by LVACTS staff. Conversion from the existing database will also be performed by LVACTS staff using, as appropriate, automated tools for calculating the new timings. The new timings will be checked at the discretion of the LVACTS System Manager. Once programmed, LVACTS staff will test the integrity of the controller program in a cabinet mock-up at the TMC. After this initial test the installation crew, consisting of a representative from the maintaining agency as well as a technician from the LVACTS staff, will transport the controller to the field for installation. The installation crew will again check the operation of the controller in the field to determine that the controller is operating as programmed.

OPERATIONAL SUPPORT I WARRANTY PERIOD

Operational support and warranty periods have been included in the specifications. Equipment furnished and installed for this project shall be guaranteed to perform according to the manufacturer's published specifications. Equipment shall also be warranted against defects and/or failure in design, materials and workmanship in accordance with the manufacturer's standard warranty. The warranty coverage shall become effective on the date of final acceptance of the hardware by NDOT. The Contractor shall assign, to NDOT, all manufacturer's normal warranties or guarantees on all such electronic, electrical, and mechanical equipment, materials, technical data, and products furnished for and installed on the project. Defective equipment shall be repaired or replaced "on-site", at the manufacturer's option, during the warranty period at no cost to LVACTS or NDOT.

TRAINING

Training will be provided on all system hardware and software components. Hardware specifications detail the training requirements that the contractors/vendors will provide to LVACTS and the local agencies. The training sessions will provide a basic understanding of the equipment/subsystems and their operational and maintenance requirements. Professional-style, in-house video taping of each of the training sessions is recommended for future use. Training will also be provided by the consultant team for LVACTS and local agency staff on system operations, software, and database management.

Operational and maintenance training will be provided to designated personnel during installation, testing, and debugging. This training will also be provided through practical demonstrations, seminars and other related technical procedures. The training proposed for LVACTS staff shall include, but not be limited to the following:

- "Hands-on" operation for each type of equipment.
- Explanation of all system commands, their function and usage.
- Required preventative maintenance procedures and schedules.
- Servicing procedures.
- System "troubleshooting" or problem identification procedures.
- Procedures for installing and setting up equipment and components.

A minimum of forty hours of instruction will be provided for the operational and maintenance procedures, unless otherwise noted in the parent specification. The Contractor will be require to submit an outline of the proposed training material for approval at least 60 days before the training is to begin.

MEDIA COORDINATION

Requests for media coverage of the system will probably increase when the system becomes operational. Coordination of these requests should be handled uniformly. Most requests will likely include access to the video surveillance subsystem. Although the system will be capable of video taping the various camera locations, no routine taping will be conducted. Video taping will only be available upon advance traffic engineering request by the OMC member agencies.

After the successful implementation of the system, a press release will be prepared and submitted to the local newspapers and television stations. To provide consistency all interviews and written correspondence will be coordinated through the System Manager as specified in the interagency LVACTS Operating Agreement.

VII. OPERATIONS AND MAINTENANCE PLAN

The continued success of any traffic signal control system depends on the commitment of the local agency(ies) to provide adequate resources for system operations and maintenance. These two critical functions have typically been underemphasized due to inadequate staff and equipment funding. Given the exceptional history of support from the member agencies of LVACTS, this system upgrade has no alternative but to succeed.

OPERATIONS

CENTRAL OPERATOR

The day-today operation of the TMC, as defined in the Interlocal Agreement, is the responsibility of the central operator, subject to review, policy guidance, and coordination by the Operations Management Committee. The City of Las Vegas has been designated as the central operator. The TMC serves as the focal point for the day-today activities related to the operation and management of the system.

Other responsibilities of the central operator include receiving and collecting operations and maintenance funds from each of the member agencies, disbursement of funds for operating and maintenance expenses, performing or supervising all maintenance and timing plan modifications deemed necessary for the efficient operation of the system.

CONTROL CENTER FUNCTIONS

LVACTS' Traffic Management Center (TMC) will continue to provide the same operations functions as currently exist. These basic operations include providing for system expansion, identifying equipment failures, trouble shooting identified problems, monitoring traffic conditions in the field, evaluating system performance, as well as developing, implementing, and fine-tuning coordinated timing plans.

HOURS OF OPERATION

The Traffic Management Center (TMC) of LVACTS is in operation Monday through Friday throughout the year, excluding holidays. The TMC operates in a split shift covering the hours from 6:00 a.m. to 6:00 p.m. During both shifts at least one technician is available for maintenance. The late shift also includes the system manager and the system software analyst. Frequently throughout the year, hours of operation are modified to accommodate evening, late night, and weekend signal timing plan implementation and fine-tuning. Routine maintenance of critical subsystems are also conducted during non-peak periods to avoid costly vehicular delays. The timing of these maintenance activities will be continued under the new system. At least one LVACTS staff member is always on-call for evening, late night, and weekend trouble calls.

MAINTENANCE

COMPONENTS

Maintenance can be broken into the functional classifications of local control, system control, and theTMC physical plant. Local control maintenance items encompass intersection vehicle and pedestrian detection, traffic signal hardware (vehicle and pedestrian signal heads, poles, mast arms, conduit, and pull boxes), emergency preemption devices, the controller cabinet, as well as the local controller hardware and timing database. System control maintenance items will consist of the backbone and local communications, the video surveillance subsystem, the system detection subsystem, local and central software, all TMC / JMC computer hardware, as well as TMC furniture. The TMC physical plant includes the building and property, the heating and air conditioning system, the electrical and phone systems, as well as the plumbing system.

RESPONSIBILITIES

Each maintenance classification has separate responsible agencies. All local control maintenance activities are overseen by the residing local agency. One clarification must be made concerning the traffic signal timing database. Two agencies, the City of Henderson and Clark County, have decided to retain responsibility and control of all noncoordination signal timing parameters. The Cities of Las Vegas and North Las Vegas, however, have agreed to let LVACTS staff modify, where needed, any signal timing parameters. The system control maintenance activities are administered through LVACTS staff. Finally, the TMC physical plant maintenance is funded and managed by LVACTS. Maintenance responsibilities for each of these classifications is detailed in **Table 6.**

LEVEL OF COMMITMENT

A critical element in the continuing success of any traffic signal system is the commitment of the participating agencies to provide sufficient personnel and equipment to operate and maintain the system. Three levels of commitment are typically evaluated for maintenan ce. The highest and most mostly level is pr*eventive* maintenance. Under this scenario the system is maintained at peak performance with little component down time. The annual cost of preventive maintenance is 10 to 15 percent of the construction budget. The next level of commitment is called acceptable maintenance. Component repairs under this scenario are prioritized and conducted as long as monies are available. The annual cost of acceptable maintenance is 5 to 7 percent of the construction budget. The final level of commitment is considered critical maintenance. Under this level only components critical to minimum system operation are guaranteed maintenance. The annual cost of critical maintenance is approximately 3 percent of the construction budget. The annual costs of these three maintenance levels are based on extensive research of other similar advanced systems and on personal experience of the system designer. The OMC will allocate all funding necessary to provide critical maintenance. In addition, the OMC will strive to provide funding for acceptable maintenance.

TABLE 6. MAINTENANCE RESPONSIBILITIES

Item No.	Maintenance Item	Responsible Agencies						
		LVACTS	NDOT	CC	CH	CLV	CNLV	MAINT.
1	Local Communications							
1 a	· Twisted-Pair Cable	P		S		S	S	
1 b	· 31 GHz	P						
1 c	· Data Radio	P						
1d	· Fiber Optic	S						P
2	Backbone Communications	S	P					S
3	Local Controller							
3a	· Hardware			P	P	P	P	
3b	• Software	P		S	S	S	S	
3c	· Actuated Timing Database	P		P	P	S	S	
3d	· Coordination Timing Database	P		S	S	S	S	
3e	· Custodian of Timing Records	P		P	P	S	S	
4	Vehicle Detection							
4a	· Intersection Detectors			P	P	P	P	
4b	· System Detectors	S						P
5	Video Surveillance Cameras	P						
6	Emergency Preemption			P	P	P	P	
7	Traffic Signal Hardware			P	P	P	P	
8	Traffic Management Center							
8a	· Building Facilities	P						
8b	· Computer Hardware	P						
8c	· System Software	P						
8d	· Furniture	P						
8e	· Office Supplies	P						
9	Jurisdictional Management Center	P		P	P		P	

LEGEND: **P** - Primary, S - Secondary, **LVACTS** - Las Vegas Area Computer Traffic System,
NDOT - Nevada Department of Transportation, CC - Clark County,
CH - City of Henderson, CLV - City of Las Vegas, **CNLV** - City of North Las Vegas,
Maint. - 3rd Party Maintenance Contractor

VIII. INSTITUTIONAL ARRANGEMENTS

The Las Vegas Area Computer Traffic System (LVACTS) has a well established track record for multi-jurisdictional cooperation and providing traffic signal coordination across jurisdictional boundaries. Having been established in 1981, LVACTS is believed to be the oldest truly multi-jurisdictional traffic signal system in the country. LVACTS is managed by its own staff and is overseen jointly by the cities of Henderson, Las Vegas, and North Las Vegas, Clark County, the Clark County Regional Transportation Commission, and the Nevada Department of Transportation. The primary contact person for each of the agencies involved with LVACTS is highlighted in **Table 7**.

The combined agencies comprise LVACTS' Operations Management Committee (OMC) and provide all infrastructure, operations, and maintenance funding. The Las *Vegas* Area Traffic Control System *Agreement* and amendments, shown in **Appendix A,** outline LVACTS and member agency responsibilities in staffmg, construction, operations, maintenance, management, and funding. A few of these responsibilities are highlighted below:

- Approving or disapproving requested additions to or deletions of traffic signals from the system.
- Formulating overall policy relative to the operation and maintenance of the LVACTS.
- Monitoring the progress of all system construction projects.
- Reviewing and discussing monthly maintenance and intersection complaint summaries.
- Monitoring on a periodic basis the functioning of LVACTS for the purpose of proposing operational changes deemed necessary to the efficient operation of the System.
- Providing instructions and directions to the Signal System Manager when requested by the manager or deemed necessary by the Committee.
- Deciding all matters which might be submitted for decision by the Signal System Manager pertaining to day-today operation and maintenance of the Traffic Control Center.
- Selecting traffic signal locations and their respective timing plans and strategies during priority time.
- Approving all staff additions and removals.
- Reviewing and approving monthly budgetary needs and expenditures of LVACTS.
- Determining whether any proposed upgrade, modifications or expansion is the result of the needs of an individual party hereto so as to be the sole financial responsibility of that party, or of benefit to the overall Traffic Control System.

The City of Las Vegas is designated as the central operator of the traffic control system. In this role the City of Las Vegas is responsible for daily operations of LVACTS, administration of budgetary items, and maintenance of communications, local controller, and TMC computer hardware and equipment. Each of the member agencies is responsible for management oversight of LVACTS and the operation of their JMC's, any construction, and system funding. The position of OMC Chairman is rotated once per year among the member agencies.

The OMC meets on the first Thursday of every month. This monthly meeting provides an opportunity for the member agencies and interested parties to review budgets, the maintenance repair report, the intersection complaint list, and other system or related business.

TABLE 7. LVACTS MEMBER AGENCY CONTACTS

Agency Name	Agency Contact	Agency Address
City of Henderson	Mr. John E. Bartels, P.E. City Traffic Engineer	City of Henderson Traffic Engineering Division 240 Water Street Henderson, NV 89101 S-7200 (702) 565-3710 (702) 565-5687 Fax
City of Las Vegas	Mr. Glenn E. Crayson, P.E. Traffic Engineer	City of Las Vegas Traffic Engineering Division 400 E. Stewart Avenue Las Vegas, NV 89101-2986 (702) 229-6327 (702) 366-0032 Fax
City of North Las Vegas	Mr. Raymond H. Burke Transportation Services Administrator	City of North Las Vegas Transportation Services Division P.O. Box 4086 North Las Vegas, NV 89030 (702) 657-2205 (702) 399-8208 Fax
Clark County	Mr. Richard T. Romer, P.E. Traffic Manager	Clark County Traffic Management Division 500 S. Grand Central Parkway Las Vegas, NV 89155 (702) 455-6100 (702) 455-6040 Fax
Clark County Regional Transportation Commission	Mr. Gary B. Johnson, P.E. Senior Engineer	Clark County Regional Transportation Commission 301 E. Clark Avenue, Suite 300 Las Vegas, NV 89101 (702) 455-4877 (702) 455-5959 Fax
Federal Highway Administration	Mr. Gregory J. Novak, P.E. Traffic & Safety Engineer	Federal Highway Administration Nevada Division 705 N. Plaza Street, Suite #220 Carson City, NV 89701 (702) 687-l 203 (702) 687-3803 Fax
Las Vegas Area Computer Traffic System	Mr. Gerard B. de Camp, P.E. System Manager	LVACTS 416 N. 8th Street Las Vegas, NV 89101 (702) 229-6611 (702) 229-6613 Fax
Nevada Department of Transportation	Mr. P.D. Kiser, P.E. Chief Traffic Engineer	Nevada Department of Transportation Traffic Engineering Division 1263 S. Stewart Street Carson City, NV 89712 (702) 687-5406 (702) 687-4846 Fax
	Mr. Gene Weight, P.E. District Engineer	Nevada Department of Transportation District 1 P.O. Box 170 Las Vegas, NV 89101 (702) 385-6500 (702) 385-6511 Fax

IX. PERSONNEL AND BUDGET RESOURCES

During 1990 the Federal Highway Administration (FHWA) conducted an extensive review of 24 traffic control systems. They found that a large majority of these systems were not operating at their full potential. The most cited problem was a lack of commitment to provide adequate staff for day-today operations and preventive maintenance. Also cited was the lack of technical knowledge of the system software and hardware as well as the general principles of traffic operations. Obviously LVACTS was not included in this review. The interjurisdictional LVACTS system, on the other hand, exemplifies a fully utilized system as a result of the entities' commitment to provide the funding and staff resources necessary for efficient operations and maintenance.

LVACTS STAFFING NEEDS

LVACTS must provide adequate operational and maintenance staffing levels and expertise for each of the system components. These components consist of the video surveillance, local control, the backbone and local communications, vehicle detection, and Traffic Management Center subsystems. Several of these subsystems will be new to the existing system operation. Therefore, extensive training and additional personnel have been recommended for LVACTS. These issues include the consolidation of detector repair / replacement, increased staff size to operate and maintain the new communications and video surveillance components, and the need to review and continually update traffic signal timing during nighttime and weekend periods.

VEHICLE DETECTION REPAIR

When the original system was started, several hundred system detectors had been installed. Due to a lack of man-power and a lack of criticality of these detectors to routine operation, only a handful of these detectors remained in operation after the first few years. Under the current LVACTS upgrade approximately 350 system detectors will again be constructed for system operations. Since vehicle detectors are the eyes of any traffic control system, maintenance of these detectors becomes paramount to continuing optimal operation. Therefore, several maintenance options were explored by the design team. The first alternative, a two-person vehicle detection repair crew, was not deemed costeffective for LVACTS unless detector repair activities of the member agencies were also combined. The second alternative, using member agency resources, was also found to be unacceptable due to a lack of personnel and / or funding for this maintenance activity. The final alternative, accepted by the OMC, consisted of developing an umbrella maintenance contract with an outside contractor. Under the latter scheme, funding would come from the responsible member agency. Most system detectors not associated with one of the special event centers will fall under NDOT's jurisdiction. Local entities can also utilize this contact for intersection detector repairs. This consolidation of detector repair activities at LVACTS will enhance daily operations by putting a higher emphasis on keeping the detection system in top condition.

REQUIRED STAFFING LEVELS

As has been discussed throughout the system upgrade, the system will have many new components that LVACTS staff does not currently know how to operate or maintain. These technical shortcomings have been overcome by the design team by integrating the LVACTS staff in the design process and by ensuring that superior training will be provided on the operation and maintenance of all system components. With the addition of 43 video surveillance cameras and a new communications system, current staffing levels will not be able to handle the increased work load.

The Las Vegas area has seen tremendous growth over the last few years. This growth has significantly hampered efficient operations of traditional off-peak periods (i.e. - nighttime and weekends) which due to Las Vegas' 2%hour lifestyle, sees much more traffic than normal. A significant effort should be made to improve and maintain these operations. This will require new staff.

Given the increase in system components, the need for off-peak timing reviews, and the need to review intersection timing information, the system's staffing needs the addition of one more Traffic Control System Technician II and one more Engineering Technician II. This additional man-power could provide a third shift for the system. The additional annual cost to LVACTS would be approximately $60,000.00. This enlarged organization of LVACTS is illustrated in Figure 6.

STAFF RESPONSIBILITIES / REQUIREMENTS

The following summaries highlight the responsibilities and requirements of the LVACTS staff. Detailed job descriptions for these positions can be found in Appendix F.

TRAFFIC SIGNAL SYSTEM MANAGER

The Traffic Signal System Manager must supervise, assign, and review LVACTS staff work for the successful day-today operations of the system. The System Manager in addition to managerial tasks must possess the technical and traffic operations knowledge necessary to ensure efficient street level operation. This individual should be registered as a Professional Engineer in the State of Nevada. Effective interfacing with the OMC, media, and public are almost as important as the technical proficiency aspect of the job.

SECRETARY

The Secretary performs a variety of administrative functions in support of the Traffic Signal System Manager and supervises the administrative support staff. Specific duties include preparing the annual budget and monthly expense reports; preparing and compiling the monthly agenda and agenda meeting packets; maintaining various system information and status reports as well as providing information and assistance regarding LVACTS policies and procedures.

OFFICE SPECIALIST I

The Office Specialist performs routine clerical duties in support of an assigned function. Duties of this position include answering phones, basic sorting, filing, copying, and the word processing of an assortment of memorandums and reports.

SYSTEMS SOFTWARE SPECIALIST

The Systems Software Specialist is essential to the success and longevity of the system. This person installs, revises, and maintains the traffic software and databases. Other tasks include software debugging and basic computer maintenance. A background in traffic engineering is an added plus for this position.

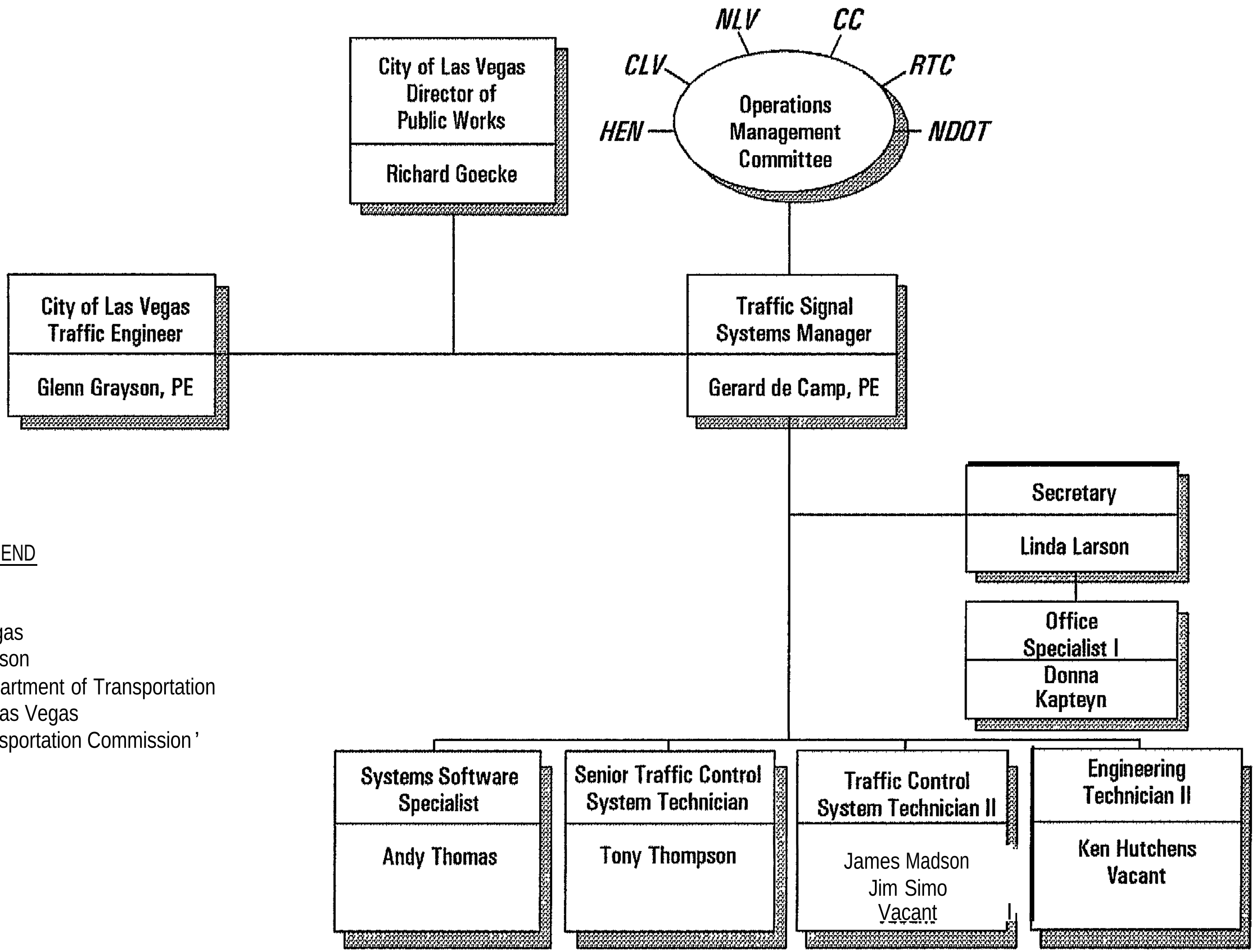
SENIOR TRAFFIC CONTROL SYSTEM TECHNICIAN

The Senior Traffic Control System Technician leads, oversees, and participates in maintaining the local

FIGURE 6.

ORGANIZATION

Las Vegas Area Computer Traffic System



LEGEND

CC - Clark County
C L V- City of Las Vegas
HEN - City of Henderson
NDOT - Nevada Department of Transportation
NLV - City of North Las Vegas
RTG - Regional Transportation Commission'

system communications and video equipment and must have a thorough understanding of the principles and operations of traffic signals. Specific tasks include complex electronic equipment repair and the development, implementation, and fine-tuning of coordinated timing plans. This individual must be fully competent in the operation of the local and the central system software.

TRAFFIC CONTROL SYSTEM TECHNICIAN II

The Traffic Control System Technician must be able to repair basic electronic components and should have a basic understanding of the principles and operations of traffic signals. Specific tasks include basic electronic equipment repair and the development, implementation, and fine-tuning of coordinated timing plans. This individual must be able to operate the local and the central system software.

ENGINEERING TECHNICAL II

The Engineering Technician assists with electronic equipment diagnostics and repair, the implementation of traffic signal timing plans, and the safe operation of a bucket truck. This individual must be able to operate the local and the central system software.

TRAINING

The Traffic Management Center will contain a multitude of staffing positions with various functions and responsibilities. Therefore, these staffing positions will need adequate training on the updated system's hardware, software, and algorithms in order to perform their jobs in a capable manner. LVACTS staff must be knowledgeable and capable of working with every aspect of this system including the central and local software, the video surveillance sub-system, the TMC hardware, the communications sub-systems, and the local control hardware. Operations, maintenance, and software training will be conducted for all existing employees toward the end of this implementation project. Each of these training session will be video-taped for use by future employees. These tapes will form the basis of the on-going training program for LVACTS staff. In addition to these tapes, the City of Las Vegas offers a host of continuing education courses that are available to all LVACTS staff members.

BUDGETARY RESOURCES

LVACTS annual operations and maintenance budgets are solely funded by the six entity-members of the Operations Management Committee (OMC). This funding breakdown is shown in Table 8. The budget for fiscal year 1996-97 includes two additional personnel and some capital expenditures for maintenance. Capital expenditures not associated with the system upgrade are also funded by the OMC members. Specifically, capital expenditures associated with the TMC building are funded by LVACTS. Contributions from the Regional Transportation Commission, if any, is determined by the member agencies of the Regional Transportation Commission.

TABLE 8. OPERATIONS AND MAINTENANCE FUNDING SOURCES	
Party	**Formula Designation**
Total Funding for LVACTS	= X + Y + (CxZ) + (HxZ) + (LxZ) + (NxZ)
NEVADA DOT	= X
REGIONAL TRANSPORTATION COMMISSION	= Y
COUNTY OF CLARK	= (CxZ)
CITY OF HENDERSON	= (HxZ)
CITY OF LAS VEGAS	= (LxZ)
CITY OF NORTH LAS VEGAS	= (NxZ)
where Z = contribution of member agencies and: C = proportion of Z contributed by CLARK COUNTY, H = proportion of Z contributed by CITY OF HENDERSON, L = proportion of Z contributed by CITY OF LAS VEGAS, N = proportion of Z contributed bv CITY OF NORTH LAS VEGAS.	

The remaining share (Z) of the funding formula shall be in an amount sufficient, when combined with the X and Y contributions, to equal the total funding requirements of the operation and maintenance of LVACTS. Funding proportions for Z represent the fractional proportion of the total number of traffic signals within LVACTS which lie within the jurisdiction of that party. On an annual basis, the Operations Management Committee, in formulating the budgetary requirements of the system, take into account any additions to, or deletions from, the system of traffic signals by a particular party. The ratio of jurisdictional signals is computed as of October 1st of the current fiscal year. The recomputed proportions become effective for the following fiscal year.

EQUIPMENT

LVACTS staff over the ten years have gradually built substantial inventory of electronic testing equipment and spare parts. Unfortunately, many of the system components being installed under the upgraded system will require more specialize equipment. Table 9 has been prepared to highlight the additional equipment that must be purchased as part of the system upgrade. Not shown on this list are the spare parts which will be supplied for the video surveillance and communications subsystems.

TABLE 9. OPERATIONS AND MAINTENANCE EQUIPMENT LIST	
Equipment Description	**Cost**
1. 65' Bucket Truck with working platform and aerial lift	$ 150,000
2. Metallic Time Domain Reflectometer	6,500
3. Optical Time Domain Reflectometer	15,000
4. Portable Color Electronic Oscilloscope (field grade with water-proof case)	5,000
5. Color Bar Generator	300
6. Spectrum Analyzer	5,000
TOTAL COSTS =	**$ 181,800**

LAS VEGAS AREA COMPUTER TRAFFIC SYSTEM

City of Las Vegas
City of North Las Vegas
County of Clark
Nevada Dept of Transportatlcn
Regional Transportation
Commission of Clark County

LETTER OF CERTIFICATION

The Operations Management Committee (OMC) of the Las Vegas Area Computer Traffic System (LVACTS) has signature approval based upon the State of Nevada Highway Agreement No. P547-80-012, effective as of January 21, 1981. The Implementation Plan for the Las Vegas Area Computer Traffic System upgrade was accepted and approved by unanimous consent of all member agencies at their September 7, 1995 meeting.

As attested to:

Gene Weight, NDOT District Engineer — Date
Operations Management Committee Chairman

Witness:

9/22/95

Gerry de Camp, Signal System Manager — Date

416 North 8th Street / Las Vegas, Nevada 89101
(702)229-6611 FAX (702) 229-6613

Hwy. Agreement No. P547-80-012

LAS VEGAS AREA
TRAFFIC CONTROL SYSTEM AGREEMENT

As amended by Amendment #1 March 19, 1991,
and Amendment #2, July 16,1991,
and Amendment #3, July 12, 1991.

THIS AGREEMENT, made and entered into this 21st day of January, 1981, by and between the CITY OF LAS VEGAS, NEVADA (alternately referred to as the "CITY OF LAS VEGAS," the "central operator" or in a collective manner with the CITY OF NORTH LAS VEGAS, NEVADA and the COUNTY OF CLARK, NEVADA as "jurisdictional operators"), the CITY OF NORTH LAS VEGAS, NEVADA and the COUNTY OF CLARK (alternately referred to as the "CITY OF NORTH LAS VEGAS" or the "COUNTY OF CLARK," respectively, or in a collective manner as "jurisdictional operators"), the CLARK COUNTY REGIONAL TRANSPORTATION COMMISSION (hereinafter referred to as the "REGIONAL TRANSPORTATION COMMISSION") and the STATE OF NEVADA (alternately referred to as " N EVADA DOT"):

WITNESSETH

WHEREAS the State of Nevada, Department of Transportation, engaged and independent consultant, PAWA, Incorporated, and Montgomery Engineers of Nevada, Incorporated, Joint Venture, to perform a signal system feasibility study for the Las Vegas Urban Area including the City of Las Vegas, City of North Las Vegas, and the County of Clark;

AND WHEREAS that report was prepared under review and supervision of each of the above named agencies;

AND WHEREAS the feasibility report recommended that traffic signals in all three above named jurisdictions be coordinated from one central traffic control center;

AND WHEREAS the above mentioned parties have approved and accepted the findings of the report;

AND WHEREAS improvement in traffic operational efficiency and monetary savings can be realized from such a consolidated management approach;

AND WHEREAS the parties hereto desire to install a Traffic Control System, hereinafter defined, for the purpose of coordinating traffic signals in the above named jurisdictions from one central traffic control center;

AND WHEREAS the parties hereto are authorized pursuant to the provisions of Chapter 277 of the Nevada Revised Statutes to enter into an interlocal agreement for the purpose of coordinating traffic signals between and within the jurisdictional boundaries of the above named jurisdictions;

NOW, THEREFORE, in consideration of the covenants and conditions herein set forth, the parties hereto mutually agree to the following:

SECTION I: SHORT TITLE

This Agreement may be referred to as the Las Vegas Area Traffic Control Agreement.

SECTION II: DEFINITIONS

HARDWARE -The physical equipment composing a computer system.

JURISDICTIONAL BOUNDARIES -The geographical boundaries of the governmental entity acting as a political subdivision of the State of Nevada.

JURISDICTIONAL CONTROL CENTER - The site or location designated by the jurisdictional operator containing various equipment capable of controlling and coordinating those traffic signals and intersections located within the jurisdictional boundaries of the jurisdictional operator.

MASTER CONTROL HARDWARE - That equipment located at the Traffic Control Center consisting of a central computer, disk storage device, teletypewriter, line printer, color cathode ray tube with keyboard, card reader, magnetic tape unit, map display, operator control panel, and map control panel, all of which are more fully described in the Las Vegas Urban Area Traffic Control Study (Final Report, March 1979) and any other similar equipment which might be added in the future.

TRAFFIC CONTROL CENTER - The site or location designated by the NEVADA DOT containing various equipment capable of controlling and coordinating the overall Traffic Control System.

PRIORITY TIME - The period of time as determined by the Operations Committee during which all traffic signals which are part of the Traffic Control System are operated and controlled according to previously approved traffic signal timing plans for the purpose of providing arterial and network coordination of traffic within and across jurisdictional boundaries.

PROJECT ADVISORY COMMITTEE -That committee created for the purpose of assisting and advising the NEVADA DOT with respect to the plans, specifications, construction and installation of the Traffic Control System and consisting of one representative from CITY OF LAS VEGAS, the CITY OF NORTH LAS VEGAS, the COUNTY OF CLARK, and the CLARK

COUNTY REGIONAL TRANSPORTATION COMMISSION.

SOFTWARE - All of the programs executed on the computer.

STRATEGY - Procedure used to determine specific traffic control measures to be applied during a control period.

TRAFFIC CONTROL SYSTEM -An array of components including traffic signal controllers, detectors, interconnect conduit and cable, interface units, computer, magnetic tape, disks, map displays, cathode ray tubes (CRT), line printer, teleprinter, operator's console, peripherals, and other related devices designed to monitor, control, and coordinate traffic movements at signalized intersections according to a given or developed plan.

TRAFFIC DETECTOR-A device located in or near the roadway which is acted upon directly by a vehicle to create a usable pulse to an intersection control device.

TRAFFIC SIGNAL LOCAL CONTROLLER - A complete electrical mechanism responsible for traffic signal control and operation at an individual intersection.

TRAFFIC SIGNAL MASTER CONTROLLER-A complete electrical mechanism responsible for traffic signal control and operation of more than one intersection in a coordinated manner.

TRAFFIC SIGNAL SUBSYSTEMS - Groups of traffic signalized intersections coordinated with their own programs, which can alternately operate as an independent system and, when traffic conditions permit, operate on the same program with adjacent subsystems to form a larger coordinated subsystem.

TRAFFIC SIGNAL TIMING PLANS - Documented hard copy which the Signal System Manager shall keep on file and supply to the jurisdictional operator. The copy shall include time space diagrams for each subsystem, signal operating parameters, proof of efficiency, and time of day operations schedules.

SECTION III: PARTIES TO THE AGREEMENT

The CITY OF HENDERSON, the CITY OF LAS VEGAS, the CITY OF NORTH LAS VEGAS, and the COUNTY OF CLARK are the designated jurisdictional operators whose responsibilities are more fully described under Section IV (B) of this Agreement.

The CITY OF LAS VEGAS is designated both a jurisdictional operator subject to the provisions of Section IV (B) of this Agreement and the central operator whose responsibilities are more fully described under Section IV (A) of this Agreement.

The NEVADA DOT is that party whose interests are limited solely to (1) installing the initial Traffic Control System within the jurisdictional boundaries of the jurisdictional operators according to the availability of federal funds or such state funds as might be approved and appropriated by the NEVADA DOT for such purpose, (2) providing, subsequent to installation, such financial assistance for the operation and maintenance of the Traffic Control System as is available from federal funding and as might be approved and appropriated by the NEVADA DOT for such purpose, and (3) serving as a voting member of the Operations Committee during the existence of this Agreement or until amended otherwise.

The REGIONAL TRANSPORTATION COMMISSION shall act solely as an interested party under this Agreement with no responsibilities, financial or otherwise for the performance of this Agreement, OTHER THAN to act as a non-voting, ex-office member of the Operations Committee.

SECTION IV: RESPONSIBILITIES OF THE CENTRAL OPERATOR, JURISDICTIONAL OPERATORS AND THE OPERATIONS COMMITTEE

A. CENTRAL OPERATOR. It is hereby agreed by and between all the parties hereto that the CITY OF LAS VEGAS is designated as the central operator of the Traffic Control System.

(1) Daily Operator: The central operator is responsible for the daily operations of the Traffic Control Center whose location shall be at a site within the jurisdictional boundaries of the City of Las Vegas, Nevada. The Traffic Control Center shall serve as the focal point for the day-today activities related to the operation and management of the Traffic Control System.

The Traffic Control Center shall consist of master control hardware capable of providing the central operator with (1) a high level of centralized system surveillance, and (2) the ability to respond quickly to traffic conditions occurring within the System.

(2) Financial Agent: It shall be the responsibility of the central operator to receive and collect from each of the parties to this Agreement their proportionate share of the operating funds as determined by the budgetary formula provided in Section V.

The Treasurer of the CITY OF LAS VEGAS shall act as the duly appointed representative on behalf of the central operator and shall have the power and authority to disburse the funds on deposit with the Treasurer for purposes of paying the operating and maintenance expenses, or other related expenses of the Traffic Control Center.

(3) Maintenance Agent: The central operator shall also be responsible for performing or supervising all maintenance deemed necessary to the Traffic Control Center by the Operations Committee. Payments of these maintenance and operation expenses shall be by the central operator from the funds allocated by the parties to this Agreement for this purpose.

(4) The central operator is authorized to engage the services of one or more consultants, in each case with the prior approval of the Operations Committee, for purposes of analyzing and making recommendations concerning improvements to and/or expansion of the computer system described in this Agreement, and for purposes of implementing said improvements and/or expansion.

B. JURISDICTIONAL OPERATORS. The CITY OF HENDERSON, CITY OF LAS VEGAS, CITY OF NORTH LAS VEGAS and the COUNTY OF CLARK shall operate their own jurisdictional management centers capable of controlling those traffic control signals located within their own jurisdictional boundaries.

(1) Equipment and Maintenance: Each jurisdictional control center shall be equipped in a manner approved by the jurisdictional operator and the NEVADA DOT. Each jurisdiction operator is responsible for the maintenance of all equipment such as, but not limited to, local controllers, interfaces, traffic detectors and communication cables located within its jurisdictional boundaries which are part of the Traffic Control System and not covered by any previously agreed to maintenance agreement.

(2) Capabilities: The jurisdictional operators shall have the capability for coordinating the timing of traffic signal subsystems within their own jurisdiction and provide such traffic signal timing as inputs to the overall timing coordination of the Traffic Control System separate and apart from the signal timing coordination necessary to the initial implementation of the Traffic Control System and any periodical retiming updates for the overall system.

(3) Modifications: Any upgrade, modification of expansion in the master control hardware or software necessitated by the traffic control needs of a party hereto shall be paid for by that party unless it is determined by the Operations Committee that the upgrade, modification or expansion benefits the overall Traffic Control System. If the Operations Committee determines that the upgrade modification or expansion benefits the overall System then the cost thereof shall be treated by the central operator like any other expense of the Traffic Control System.

C. OPERATIONS COMMITTEE.

(1) Membership and Meetings: The Operations Committee shall be composed of representatives from the parties to this Agreement in the following manner:

Party	Membership Number
NEVADA DOT	1
REGIONAL TRANSPORTATION COMMISSION	1

(Non-voting, ex officio member)

COUNTY OF CLARK	1
CITY OF LAS VEGAS	1
CITY OF NORTH LAS VEGAS	1
CITY OF HENDERSON	1

The representative designated on behalf of each party shall be selected from among the following: The Director of Public Works or City Traffic Engineer for the CITY OF HENDERSON, the Director of Public Works or City Traffic Engineer for the CITY OF LAS VEGAS, the Director of Public Works or Transportation Services Administrator for the CITY OF NORTH LAS VEGAS, the Director of Public Works or the Traffic Manager for the COUNTY OF CLARK, the Director, Deputy Director or the District Engineer of the NEVADA DOT, and the Director of the CLARK COUNTY REGIONAL TRANSPORTATION COMMISSION. Each representative shall have a designated alternate with full authority to act in the absence of the representative. The Operations Committee may be expanded to include other additional members as approved by majority vote of the members of the existing Operations Committee.

The Operations Committee shall meet minimally on a monthly basis but may meet more frequently if the problems or business of the Operations Committee necessitate such additional meetings. The chairperson of the Operations Committee shall have the authority to call a meeting of the Committee with a minimum of seven (7) calendar days' notice to all the members. Notice is deemed to have occurred from the date that it is deposited with the United States Postal Service, postage prepaid, addressed to the members of the Operations Committee.

(2) Chairperson and Vice-Chairperson: In the first meeting of the Operations Committee, the members shall proceed to elect by majority vote of all of the voting members of the Committee, from amongst the members of the Committee, a chairperson and vice-chairperson who will serve a term of one year. Thereafter, a chairperson and vice-chairperson will be elected by a majority vote of all the voting members of the Committee on an annual basis. Said election will occur at the last regularly scheduled meeting of the Operations Committee prior to the expiration of the chairperson's and vice-chairperson's one-year term. All Committee records shall be maintained in accordance with NRS Chapter 241 on public records at the Traffic Control Center.

(3) Quorum and Voting: Except for the REGIONAL TRANSPORTATION COMMISSION, all members of the Operations Committee shall be entitled to one vote on all matters submitted to the Committee for vote. The REGIONAL

TRANSPORTATION COMMISSION shall have a representative on the Operations Committee who shall act solely in a non-voting ex officio capacity.

Any three of the voting members of the Operations Committee shall constitute the quorum necessary to convene the meeting of the Committee. All official action by the Operations Committee shall require a majority vote of the members present at the meeting.

Each member shall have the power to recall any matter voted upon during his absence at a regularly scheduled meeting if prior to the next regularly scheduled meeting said member informs the Chairperson in writing in sufficient time to comply with all the notice requirements of the Open Meeting Law (Chapter 241 of the Nevada Revised Statutes and any subsequent amendments thereto) and at least ten (10) days prior to the date of the next regularly scheduled meeting of his intent to subject the previously approved or disapproved matter to revote of the then present members. If a previously voting member is not present for the revote, then said member is deemed to cast his or her vote in the same manner as previously voted on the matter.

(4) Responsibilities: The Operations Committee shall be responsible for the following:

(a) Formulating overall policy relative to the operation and maintenance of the Traffic Control Center;

(b) Monitoring the progress of the installation of the Traffic Control System;

(c) Monitoring on a periodic basis the functioning of the Traffic Control System for the purpose of proposing operational changes deemed necessary to the efficient operation of the System;

(d) Providing instructions and directions to the Signal System Manager when requested by the manager or deemed necessary by the Committee;

(e) Deciding all matters which might be submitted for decision by the Signal System Manager pertaining to day-today operation and maintenance of the Traffic Control Center;

(f) Selecting those traffic signal timing plans and strategy to be in effect for the Traffic Control System during priority time;

(g) Filing an annual report with the various governmental entities with membership on the Operations Committee detailing the performance of the Traffic Control System and recommending possible improvements to the System;

(h) Approving or disapproving the requested additions to or deletions of traffic signals from the Traffic Control System by one of the parties pursuant to the provisions of Section VI B (3) of this Agreement;

(i) Approving the creation of new employee positions in connection with the operation of the Traffic Control Center;

(j) Approving the deletion of existing employee positions in connection with the operation of the Traffic Control Center;

(k) Reviewing all proposed selections, terminations, classifications or other personnel actions with respect to employees in the Traffic Control Center for the purpose of formulating their recommendations on such action for consideration by the central operator;

(l) Reviewing and approving monthly the budgetary needs and expenditures of the Traffic Control Center;

(m) Determining whether any proposed upgrade, modifications or expansion is the result of the needs of an individual party hereto so as to be the sole financial responsibility of that party, or of benefit to the overall Traffic Control System.

SECTION V: DESIGN AND IMPLEMENTATION

A. GENERAL. The NEVADA DOT shall be responsible for initiating and supervising installation of all new equipment, or the restructuring of existing equipment necessary to the installation and operation of the Traffic Control System.

B. PLANS AND SPECIFICATIONS. Implementation and installation of the components of the initial Traffic Control System will be according to plans and specifications prepared on behalf of the NEVADA DOT and which are reviewed and approved by the other parties to this Agreement. The implementation of the project plans and specifications shall be the prime responsibility of the NEVADA DOT with monitoring by the members of the Project Advisory Committee, and if desirable by the Operations Committee for the purpose of recommending changes to the NEVADA DOT in the implementation of those plans and specifications.

C. TRANSPORTATION MANAGEMENT CENTER. The NEVADA DOT shall designate on state owned property the location of, and shall construct thereon according to the design recommended by the Las Vegas Urban Area Traffic Control System Study (Final Report, March 1979), the Traffic Control Center. The master control hardware, and any other equipment necessary to the operation of the Traffic Control Center shall be provided by the NEVADA DOT through the use of federal funds or such state funds as might be appropriated by the NEVADA DOT. Title to the property, building, master control hardware and any other equipment therein shall remain in the name of the STATE OF NEVADA.

D. JURISDICTIONAL CONTROL CENTER. The NEVADA DOT shall be responsible for installing, at its own expense, a map display, control console with line printer and cathode ray tube at the location designated by the jurisdictional operator as the site of the Jurisdictional Control Center. Any additional or duplicative equipment shall be the responsibility, both installation and maintenance expense, of the jurisdictional operators. Title to all of the equipment installed by the NEVADA DOT at the Jurisdictional Control Center as part of the Traffic Control System shall remain in the name of the State of Nevada.

E. LOCAL CONTROLLERS AND MASTER LOCAL CONTROLLERS. The NEVADA DOT shall also be responsible, where federally funded, or state funds are specifically approved and appropriated by the NEVADA DOT, for **(1)** converting and incorporating those functionally adequate local controllers already located at the traffic signal intersections into the Traffic Control System, or **(2)** replacing those local controllers which are functionally inadequate, and incapable of being incorporated into the Traffic Control System. All existing traffic signal equipment which is replaced or removed shall be returned to the owners. Ownership of the newly installed local controllers and master controllers, installed with Federal Funds, shall remain vested in the name of the State.

F. COMMUNICATION COMPONENTS AND TRAFFIC DETECTORS. The NEVADA DOT shall also be responsible, at its own expense, for the installation at the site of various traffic control signals, the traffic detectors and communication components necessary to the operation of the Traffic Control System.

G. The CITY OF HENDERSON shall arrange to secure all funding necessary for the provision and installation of all Jurisdictional Control Center and local intersection control equipment required to connect the CITY OF HENDERSON to the system. No cost of adding the CITY OF HENDERSON or any CITY OF HENDERSON traffic signals to the Las Vegas Area Traffic Control System shall be borne by the Las Vegas Area Traffic Control System local jurisdictional operating agency. Title and ownership of all equipment provided and installed in connection with the extension of the Las Vegas Area Traffic Control System to the CITY OF HENDERSON shall be vested as the funding agency requires.

SECTION VI: FUNDING

A. IMPLEMENTATION AND INSTALLATION EXPENSES. The NEVADA DOT shall be responsible for payment of all costs for installing the initial Traffic Control System where federal funds are available for payment of such costs. If federal funds are not available for the payment of such costs, then the NEVADA DOT may, at its option, appropriate state funds for such costs. The jurisdictional operators are not responsible for the payment of any installation costs unless approval has been given by the governing body of each jurisdictional operator.

B. OPERATION AND MAINTENANCE EXPENSES.

(1) Collection and Disbursal of Funds: At the beginning of each quarter of the fiscal year the central operator shall notify the parties to this Agreement as to the amount of their funding share in the cost of operating and maintaining the Traffic Control Center for that quarter. Within thirty (30) days from notification, the parties shall remit to the central operator their contribution to the funding of the Traffic Control Center as determined by the formula hereinafter provided under this Section.

Funds derived from the individual parties according to their predetermined share shall be deposited by the central operator into an account established solely for the purpose of paying operation and maintenance expenses of the Traffic Control Center. The Treasurer of the CITY OF LAS VEGAS shall have authority to issue drafts against said account for expenses approved by the Operations Committee. Any interest which may accrue to the funds received from the parties hereto shall be credited by the City Treasurer to said account for the benefit of all the parties to this Agreement.

(2) Annual Budget: The Signal Systems Manager shall prepare prior to the commencement of the next fiscal year an operations and maintenance budget which shall be submitted to the Operations Committee for review and approval according to the time schedule established by the Operations Committee. Immediately upon approval by the Operations Committee, the proposed budget shall be submitted for review and approval to the governing bodies of all the parties hereto except the NEVADA DOT and the REGIONAL TRANSPORTATION COMMISSION. Approval or disapproval of the proposed budget shall occur no later than thirty (30) days from submission to the parties.

If a party disapproves the proposed budget, then the basis of the disapproval shall be stated in writing, and the proposed budget shall be referred back to the

Operations Committee for revision. Upon completing the revisions, the budget shall be resubmitted to the same parties for review and approval,

(3) Funding Formula: The contributions of each party to this Agreement shall be determined in accordance with the following formula:

Total Funding of the Traffic Control Center = X+Y+(CxZ)+(HxZ)+(LxZ)+(NxZ)

Party		Formula Designation
NEVADA DOT	=	X
REGIONAL TRANSPORTATION COMMISSION	=	Y
COUNTY OF CLARK	=	(CxZ)
CITY OF HENDERSON	=	(HxZ)
CITY OF LAS VEGAS	=	(LxZ)
CITY OF NORTH LAS VEGAS	=	(NxZ)

where Z = contribution of member agencies and:
C = proportion of Z contributed by CLARK COUNTY,
H = proportion of Z contributed by CITY OF HENDERSON,
L = proportion of Z contributed by CITY OF LAS VEGAS,
N = proportion of Z contributed by CITY OF NORTH LAS VEGAS.

The contribution of the NEVADA DOT (X) shall be limited to that portion, if any, which is reimbursable by the federal government and which the NEVADA DOT elects to approve and appropriate for purposes of this Agreement. The contribution of the REGIONAL TRANSPORTATION COMMISSION (Y), if any, is to be determined by. the members of the Regional Transportation Commission.

The remaining share (Z) of the funding formula shall be in an amount sufficient, when combined with the X and Y contributions, to equal the total funding requirements of the operation and maintenance of the Traffic Control Center. At the commencement of Amendment No. 3, the contributions of the COUNTY OF CLARK, the CITY OF HENDERSON, the CITY OF LAS VEGAS, and the CITY OF NORTH LAS VEGAS shall be according to the fractional proportions stated above for the Z portion of the funding formula which represents the fractional proportion of the total number of traffic signals within the Traffic Control System which lie within the jurisdiction of that party. On an annual basis, the Operations Committee, in formulating the budgetary requirements of the Traffic Control System, shall take into account any additions to, or deletions from, the system of traffic signals by a particular party, and shall recompute (to the nearest 0.1%) the increase or decrease in the fractional proportion of the party's ratio to the total number of traffic signals within the system as exists on October 1 of the current fiscal year. The recomputed proportions shall be effective for the following fiscal year.

It is agreed by and between the parties hereto that in the event a party, for whatever reason, desires to delete any traffic signal(s) within its jurisdiction from control by the Traffic Control System, that notice of such intent shall be conveyed in writing to the Operations Committee seven (7) months before the close of the then current fiscal year, and that in no event shall the proposed number of traffic signals to be deleted exceed ten percent (10%) of the total number of traffic signals located within the jurisdiction of the party proposing the deletion. Any and all proposed deletions must be approved by the Operations Committee as required by the provisions of Section IV C (4) (h) of this Agreement.

If a party so elects to delete any of its traffic control signals from the System, then this traffic control signal may not be re-added to the System until the following fiscal year and only with the approval of the Operations Committee. In the event that a traffic signal(s) is so deleted from the System, the Operations Committee reserves the right to require, at the expense of the deleting party, the return of any and all equipment located at the site of the traffic control signal(s) which was installed by the NEVADA DOT as part of the initial installation and implementation of this System, EXCEPTING THEREFROM underground equipment and those local controllers or other equipment installed as replacements of previously existing local controllers or other equipment necessary to the operation of the traffic signal.

(4) Covered Expenses: All expenses in connection with the operation and maintenance of the Traffic Control Center, including, but not necessarily limited to, staffing, control equipment maintenance contracts, routine central maintenance, new equipment costs, building repair expenses and office operating expenses shall be paid by the central operator from the funds allocated by the parries under the funding formula provided for under Section VI of this Agreement.

All other expenses associated with the operation and maintenance of the Jurisdictional Control Center, such as, but not necessarily limited to, control, communication and monitoring equipment, staffing, field maintenance and office operating expenses shall be the sole responsibility of the jurisdictional operator.

SECTION VII: SYSTEM OPERATION

The day-today operation of the Traffic Control System shall be the responsibility of the central operator, subject to review and coordination by the Operations Committee.

A. SIGNAL CONTROL STRATEGY. The central operator shall operate the Traffic Control System in accordance with the operation strategy recommended by the Las Vegas Urban Area Traffic Control System Study (Final Report, March 1979). Subsequent deviations or changes in the initially adopted and implemented operational strategy, responding to newly identified needs of the Traffic Control System (such as the updating of signal timing plans), shall be approved by the Operations Committee.

B. OPERATION. During that period of time determined to be priority time by the Operations Committee, the Traffic Control Center shall preempt the control of those traffic signal subsystems and individual traffic signals located within the jurisdictional boundaries of the jurisdictional operators for purposes of providing arterial and network coordination according to previously approved traffic signal timing plans. During periods of non-priority time, the jurisdictional operator may, at its option, provide the central operator with its own traffic signal timing plans and strategy, to be implemented by the central operator, for the purpose of controlling traffic within the boundaries of the jurisdictional operator.

SECTION VIII: EMPLOYEES AND DUTIES

A. TRAFFIC CONTROL CENTER. The central operator is hereby authorized to employ at the Traffic Control Center the following employees in accordance with an approved table of organization (attached hereto as Exhibit “A” and incorporated herein as a part of this Agreement):

(1) Signal System Manager: Subsequent to executing this Agreement and during the installation of the Traffic Control System, the central operator shall employ a Signal System Manager who shall be responsible for (a) advising the NEVADA DOT as to matters concerning the installation of the Traffic Control System. (b) becoming familiar with all facets of the Traffic Control System installation for informational purposes and for possible future recall, (c) supervising all personnel employed in connection with the operation and maintenance of the Traffic Control Center, (d) supervising the maintenance of all equipment located at the Traffic Control Center, and field maintenance of communication components necessary to the operation of the Traffic Control System, (e) implementing change in operational strategy as approved by the Operations Committee, (f) collection and logging system evaluation data and information, (g) supervising the implementation of those traffic signal timing plans submitted by the jurisdictional operators, (h) preparing a monthly expenditure report for

review by the Operations Committee, and (i) generally deciding those day-to-day managerial decisions which cannot be submitted to the Operations Committee until the next regularly scheduled meeting.

The Operations Committee shall be advised by the Signal System Manager as to the problems of, and needed changes in, the operation strategies of the system and as to any other matter pertinent to the operation of the system.

The Signal System Manager shall also assume the responsibilities of all public relations with respect to the operation and maintenance of the Traffic Control System.

(2) Operator/Technician: The central operator shall employ the necessary operator/technician(s) who shall be responsible for (a) manning and operating the Traffic Control Center during designated operational hours, (b) monitoring the operation of the system, (c) responding to malfunctions in equipment of the Traffic Control System located at the Traffic Control Center, Jurisdictional Control Centers or at the intersections of traffic signals within the system, whose repair if the responsibility of the central operator, and (d) notifying the field maintenance personnel of the jurisdictional operators as to malfunctions in equipment which is part of the Traffic Control System but whose responsibility for repair remains that of the jurisdictional operator. The number of operator/technician positions shall be determined by the Operations Committee.

(3) Software Analyst: The central operator shall employ a software analyst(s) who shall be responsible for (a) updating the data base of the traffic control computer, (b) implementing minor software changes to the system’s software which do not change timing parameters so as to necessitate the approval of the Operations Committee, (c) assisting any person designated to implement major software changes approved by the Operations Committee, (d) coordinating and collecting operational data on the Traffic Control System for purposes of evaluating the system’s performance, (e) assisting, when needed, in rectifying malfunctions of the system’s hardware, and (f) conducting special data studies requested by the central operator or the jurisdictional operators. The number of software/analyst positions shall be determined by the Operations Committee.

(4) Clerical Employees: The central operator may also employ such clerical employees as deemed necessary to the efficient operation of the Traffic Control System and the Traffic Control Center. The number of clerical positions shall be determined by the Operations Committee.

All of the abovedescribed positions shall be employees of the central operator. The amount of compensation to be paid to said employee shall be recommended by the Operations Committee and approved by the central operator. The selection, termination, classification or any other personnel action pertaining to an employee to the above-described positions shall be determined by the central operator in accordance with its personnel rules, regulations and procedures.

Any and all proposed selections, terminations, classifications or other personnel actions with respect to these employees shall be reviewed by the Operations Committee to formulate their recommendations with respect to the aforementioned actions. The central operator shall consider the recommendations of the Operations Committee before selecting, terminating, classifying or taking any other personnel action with respect to any employee.

The Operations Committee shall approve any proposed additional slots in the above-described positions, reductions thereof or the creation of any new position.

B. JURISDICTIONAL CONTROL CENTER. Staffing at the Jurisdictional Control Center shall be at the discretion of the jurisdictional operator.

SECTION IX: INSURANCE AND INDEMNITY

A. INSTALLATION PERIOD. It is further understood that the NEVADA DOT will be responsible for any loss, damage, liability, cost or expense caused by the actions or non-actions of its employees, servants or agents which may arise under this Agreement.

B. POST INSTALLATION INSURANCE. It is mutually agreed by and between the parties hereto that subsequent to the acceptance of the installed Traffic Control System by, and within the jurisdictional boundaries of, the CITY OF LAS VEGAS, the COUNTY OF CLARK, and the CITY OF NORTH LAS VEGAS that the central operator and the jurisdictional operators each agree to be solely and separately responsible for all claims, demands, actions, damages, decrees, judgements, attorney fees, costs, and expenses resulting from injuries or damages to persons or properties within their own jurisdictional boundaries resulting from, arising out of, or due to the operation or maintenance of the Traffic Control System. It is further agreed by the party in whose jurisdiction the injury or damage to person or property has occurred to indemnify, defend and hold harmless the other parties hereto, or any of its officers or employees from any and all claims, demands, actions, damages, decrees, judgments, attorney fees, costs and expenses which said party, its officers or employees any suffer, or which may be sought against, recovered from, or obtainable against said party, its officers or employees.

C. Jurisdictional Insurance and Indemnity: The CITY OF HENDERSON shall be solely and separately responsible for all claims, demands, actions, damages, decrees, judgments, attorney fees, costs, and expenses resulting from injuries or damages to persons or properties within their own jurisdictional boundaries resulting from, arising out of, or due to the operation or maintenance of the Traffic Control System. It is further agreed by the CITY OF HENDERSON, when the injury or damage to person or property has occurred in its jurisdiction, that it shall indemnify, defend and hold harmless the other parties hereto, or any of its officers or employees from any and all claims, demands, actions, damages, decrees, judgments, attorney fees, costs and expenses which the CITY OF HENDERSON, its officers or employees may suffer, or which may be sought against, recovered from, or obtainable against said party, its officers or employees.

SECTION X: DURATION OF AGREEMENT

This Agreement shall be perpetually binding upon the parties hereto unless a date of termination is agreed upon by all the parties.

SECTION XI: TITLE OF PROPERTY ACQUIRED WITH COMMON FUNDS

A. Title and ownership of all property which is acquired with funds appropriated by the parties other than the NEVADA DOT under this Agreement shall be determined in the following manner:

(1) Any and all property installed at the site of a traffic signal shall vest in title and ownership in the name of the party in whose jurisdiction the property is located;

(2) Any and all property installed at a jurisdictional management center shall vest in title and ownership in the name of the jurisdictional operator;

(3) Any and all property installed at the Traffic Control Center shall vest jointly in title and ownership in the name of the funding parties hereto according to the percentage of their contribution to the overall funding of the Traffic Control System during the fiscal year of acquisition. However, any joint owner or the State of Nevada may offer to acquire said property under terms agreed to by all the joint owners.

B. Title and ownership of all property which is acquired with funds appropriated by the NEVADA DOT shall vest in the name of the NEVADA DOT, except that where such property is acquired with funds appropriated by the NEVADA DOT, COUNTY OF CLARK, CITY OF HENDERSON, CITY OF LAS VEGAS, and the CITY OF NORTH LAS

VEGAS then the title and ownership shall vest jointly to the extent of each party's contribution. However, any joint owner may offer to acquire said property under terms agreed to by all the parties.

SECTION XII: SEVERABILITY

It is understood and agreed by the parties hereto that if any part, term or provision of this Agreement declared by a court of competent jurisdiction to be illegal or in conflict with any laws of this State, the validity of the remaining portions or provisions shall not be affected, and the rights and obligations of the parties shall be construed and enforced as if the Agreement did not contain the particular part, term or provision held to be invalid.

TRAFFIC SIGNAL SYSTEMS MANAGER

Class specifications are intended to present a descriptive list of the range of duties performed by employees in the class. Specifications are not intended to reflect all duties performed within the job.

DEFINITION

To supervise, assign and review the work of staff responsible for the day-to-day operations of the Las Vegas Area Computer Traffic System (LVACTS), as required by LVACTS' governing inter-agency operating agreement; to oversee and participate in all work activities; and to perform a variety of technical tasks relative to assigned area of responsibility.

SUPERVISION RECEIVED AND EXERCISED

Receives administrative direction from the City Traffic Engineer and the Operations Management Committee.

Exercises direct supervision over technical and clerical staff.

ESSENTIAL FUCTION STATEMENT - Essential responsibilties and duties may include, but are not limited to, the following:

Essential Functions:

1. Plan, prioritize, assign, supervise and review the work of staff responsible for the Las Vegas Area Computer Traffic System.
2. Recommend and assist in the implementation of goals and objectives; implement approved policies and procedures.
3. Establish schedules and methods for providing traffic signal services; identify resource needs; review needs with appropriate management staff, allocate resources accordingly.
4. Evaluate and monitor operations and performance of coordinated traffic signals in the field, and make or direct appropriate major and minor adjustments and revisions within complex engineering constraints.
5. Participate in the selection of traffic control system staff; provide or coordinate staff training; work with employees to correct deficiencies; implement discipline procedures.
6. Participate in the preparation and administration of the traffic control system budget; submit budget recommendations; monitor expenditures.
7. Represent the Las Vegas Area Computer Traffic System at regular formal and informal interagency meetings of traffic engineers and elected officials.
8. Represent the City at public relations functions for the system, including providing interviews periodically requested by the press and responding to often technically difficult questions and

complaints from elected officials and the public.

9. Prepare analytical and statistical reports on operations and activities.
10. Serve as executive board secretary to the LVACTS Operations Management Committee (OMC), directing staff production of meeting agenda, minutes, and related technical and administrative reports and memoranda.
11. Establish and develop ideas for advanced and unusual engineering improvements to traffic signal operations to meet the needs of heavy traffic loads, and related equipment revisions and customized electrical circuitry necessary to implement them.
12. Attend and participate in professional group meetings; stay abreast of new trends and innovations in the field of traffic signal control systems.
13. Perform related duties and responsibilities as required.

QUALIFICATIONS

Knowledge of:

- Operations, services and activities of a computerized traffic control program.
- Principles of supervision, training and performance evaluation.
- Modem and complex principles and practices of traffic control systems.
- Principles and practices of engineering and transportation planning.
- Principles of electricity.
- City traffic ordinances and street system.
- Operations of a central computer control system used for traffic signal system applications.
- Pertinent Federal, State, and local laws, codes and regulations.

Ability to:

- Supervise, organize, and review the work of lower level staff.
- Select, supervise, train and evaluate staff.
- Analyze field traffic observations and evaluate the engineering techniques by which traffic flow could be improved.
- Review all subdivision and construction plans to assure compliance with City traffic ordinances to analyze road capacities.
- Determine and recommend solutions to traffic congestion.
- Conduct studies of traffic volumes, peak loads, origins, destinations and related issues.

Ability to:

- Review and plan necessary detours for construction projects to determine location, type and specifications for new traffic control devices.
- Oversee the installation and maintenance of uniform traffic signs and signals, parking meters, and pavement markings.
- Interpret and explain City policies and procedures.

Prepare clear and concise reports.
Communicate clearly and concisely, both orally and in writing.
Establish and maintain effective working relationships with those contacted in the course of work including City officials and the general public.
Maintain effective audio-visual discrimination and perception needed for:

Making observations
Communicating with others
Reading and writing
Operating assigned equipment.

Maintain mental capacity which allows the capability of:

Making sound decisions
Demonstrating intellectual capabilities.

Experience and Training Guidelines

Any combination of experience and training that would likely provide the required knowledge and abilities is qualifying. A typical way to obtain *the* knowledge *and abilities would be:*

Experience:

Four years of increasingly responsible managerial, administrative, or supervisory experience in the field of traffic engineering. Experience with computerized traffic control systems and public relations is preferable.

Training:

Equivalent to a Bachelors degree from an accredited college or university with major course work in civil transportation or engineering or a related field.

License or Certificate

Must possess registration as a Professional Engineer in the state of origin and must obtain Nevada registration within one year of appointment.

SECRETARY

C/ass specifications are intended to present a descriptive list of the range of duties performed by employees in the class. Specifications are not intended to reflect all duties performed within the job.

DEFINITION

To perform a wide variety of responsible administrative clerical work in support of a division manager; to type and proofread a variety of documents and correspondence; and to provide information and assistance to the public regarding division policies and procedures.

DISTINGUISHING CHARACTERISTICS

The Secretary is distinguished from the Senior Secretary by the performance of journey level secretarial duties related to providing and coordinating support services for a division manager. This class performs typing or word processing of reports and correspondence and compiles a wide variety of statistical data. This class performs the full range of secretarial and clerical duties as assigned.

SUPERVISION RECEIVED AND EXERCISED

Receives general supervision from a division manager.

May exercise direct supervision over lower level clerical staff.

ESSENTIAL AND MARGINAL FUNCTION STATEMENT- Essential and other important responsibilities and duties may include, but are not limited to, the following:

Essential Functions:

1. Coordinate and provide support services for a division manager; monitor workload, work activities, priorities and deadlines.
2. Respond to public inquiries in a courteous manner; provide information within the area of assignment; resolve complaints in an efficient and timely manner.
3. Answer the telephone and wait on the general public; provide information on departmental and City policies and procedures as required.
4. Maintain a calendar of activities, meetings and various events for assigned division manager; coordinate activities with other City divisions or departments, the public and outside agencies; make travel arrangements as required.
5. Prepare, type, word process and proofread a variety of documents including general correspondence, agendas, reports, memoranda and statistical charts from rough draft,

dictaphone, or verbal instruction.

6. Maintain records and develop reports concerning new or ongoing programs and program effectiveness; maintain records for attendance, facilities usage, service levels, permits or related records; prepare statistical reports as required.
7. Perform a wide variety of general clerical work including the maintenance of accurate and detailed logs and records; verify accuracy of information, research discrepancies and record information.
8. Operate a variety of office equipment including a switchboard, copiers, facsimile machines and computers; input and retrieve data and text; organize and maintain disk storage and filing.
9. Compile information and data for statistical and financial reports; maintain a variety of statistical records; check and tabulate statistical data.
10. Provide information and forms to the public as needed; apply departmental policies and procedures in determining completeness of applications, forms, records and reports.

Marginal Functions:

1. May take minutes for assigned boards and committees; prepare and distribute agendas.
2. Contact the public and outside agencies in acquiring and providing information and making referrals.
3. Receive, sort and distribute incoming and outgoing correspondence.
4. Perform related duties and responsibilities as required.

QUALIFICATIONS

Knowledge of:

Operations, services, and activities of an assigned division.
Principles of business letter writing and basic report preparation.
Practices used in minute taking and preparation.
Modern office procedures, methods and computer equipment.
Fundamental principles and procedures of record keeping.
English usage, spelling, grammar and punctuation.

Coordinate, organize and review the work of staff in the area of work assigned.
Independently perform the most difficult administrative support services.
Interpret, explain and enforce division policies and procedures.
Perform responsible secretarial work involving the use of independent judgment and personal initiative.
Understand the organization and operation of the City and of outside agencies as necessary to assume assigned responsibilities.

Ability to:

Perform clerical work including maintenance of appropriate records and compiling information for reports.
Work independently in the absence of supervision. Type 50 words per minute.
Take shorthand at 80 words per minute.
Operate a variety of office machines including a computer. Perform routine mathematical calculations.
Respond to requests and inquiries from the general public.
Understand and carry out oral and written directions.
Communicate clearly and concisely, both orally and in writing.
Establish and maintain effective working relationships with those contacted in the course of work.
Maintain mental capacity which allows for effective interaction and communication with others, Maintain physical condition appropriate to the performance of assigned duties and responsibilities which may include the following:

sitting for extended periods of time
operating assigned equipment.

Maintain effective audio-visual discrimination and perception needed for:

making observations
communicating with others
reading and writing
operating assigned equipment.

Experience and Training Guidelines

Any combination of experience and training that would likely provide the required knowledge and abilities is qualifying. A typical way to obtain the knowledge and abilities would be:

Experience:

Three years of responsible secretarial and clerical experience.

Training:

Equivalent to graduation from high school, supplemented by specialized secretarial training.

License or Certificate

May require possession of, or ability to obtain, an appropriate, valid Notary Public Certification.

WORKING CONDITIONS

Environmental Conditions:

Office environment; exposure to computer screens.

Physical Conditions:

Essential and marginal functions require maintaining physical condition necessary for sitting for prolonged periods of time.

OFFICE SPECIALIST I

C/ass specifications are intended to present a descriptive list of the range of duties performed by employees in the class. Specifications are not intended to reflect all duties performed within the job.

DEFINITION

To perform routine clerical duties in support of an assigned function; to act as a receptionist; to assist and inform the public in person or on the telephone, on departmental policies and procedures; and to provide basic sorting, filing, copying or clerical accounting services.

DISTINGUISHING CHARACTERISTICS

This is the entry level class in the Office Specialist series. This class is distinguished from the Office Specialist II by the performance of the more routine tasks and duties assigned to positions within the series including filing, copying, and receptionist duties. Since this class is typically used as a training class, employees may have only limited or no directly related work experience.

$UPERVISION RECEIVED AND EXERCISED

Receives immediate supervision from higher level supervisory or management staff.

EXAMPLES OF IMPORTANT RESPONSIBILITIES AND DUTIES-important responsibilities and duties may include, but are not limited to, the following:

Essential Functions:

1. Act as a receptionist; answer the telephone and wait on the general public; provide information on City policies and procedures as required.
2. Perform a variety of routine record keeping duties, such as filing and maintaining ledgers, logbooks and bookkeeping records; research and resolve discrepancies as needed.
3. Enter and update a variety of departmental data into computer terminal; type a wide variety of documents and forms; retrieve data as necessary; operate a printer and other computer peripherals.
4. Provide information and forms to the public; collect and process appropriate fees and information; make and distribute copies as necessary; receive, sort and distribute incoming and outgoing mail.
5. Schedule client appointments for department staff; maintain appointment books and type daily staff schedules.

6. Operate a variety of office machines including a photocopier, adding and calculating machine, typewriter, computer terminal, and microfilm machine.

Marginal Functions:

1. Contact outside agencies and the general public to acquire and provide information.
2. Perform related duties and responsibilities as assigned.

QUALIFICATIONS

Knowledge:

Modern office procedures, methods and computer equipment.
Principles and procedures of filing and record keeping.
English usage, spelling, grammar and punctuation.
Basic arithmetic.

Ability to:

Learn to correctly interpret and apply City policies and procedures.
Perform general clerical work including maintaining files and compiling information for reports.
Type 35 words per minute.
Operate standard office machines including a word processor or computer.
Understand and follow oral and written instructions.
Communicate clearly and concisely, both orally and in writing.
Establish and maintain cooperative working relationships with those contacted in the course of work.
Maintain mental capacity which allows for effective interaction and communication with others.
Maintain physical condition appropriate to the performance of assigned duties and responsibilities which may include the following:

sitting for extended periods of time
operating assigned equipment.

Maintain effective audio-visual discrimination and perception needed for:

making observations
communicating with others
reading and writing
operating assigned equipment.

Experience and Training Guidelines

Any combination of experience and training that would likely provide the required know/edge and abilities is qualifying. A typical way to obtain the knowledge and abilities would be:

Experience;

One year of clerical experience including public contact is desirable.

Training:

Equivalent to graduation from high school.

WORKING CONDITIONS

Environmental Conditions;

Office environment; exposure to computer screens.

Physical Conditions:

Essential and marginal functions require maintaining physical condition necessary for sitting for prolonged periods of time.

SYSTEMS SOFTWARE SPECIALIST

C/ass specifications are intended to present a descriptive list of the range of duties performed by employees in the class. Specifications are not intended to reflect all duties performed within the job.

DEFINITION

To install, revise and maintain software and databases of a large computer system; to resolve computer system software problems; and to maintain computer equipment.

SUPERVISION RECEIVED AND EXERCISED

Receives direction from higher level management staff.

ESSENTIAL FUNCTION STATEMENTS-Essential responsibilities and duties may include, but are not limited to, the following:

Essential Functions;

1. Install and maintain mainframe operating system software.
2. Create and update databases and database software.
3. Create and update data communication networks for mainframe terminals and printers.
4. Create programs and procedures to improve or supplement system and application software.
5. Troubleshoot and resolve operating system, database and data communication problems; recommend new equipment as appropriate.
6. Assist programming staff in resolving application software problems.
7. Coordinate system and application software for maximum efficiency; work with staff in evaluating system; recommend changes or upgrades.
8. Evaluate and install software packages supplied by vendors; confer with vendors on software and hardware technical issues.
9. Develop procedures to minimize system downtime; provide technical support for maintaining the system.
10. Conduct studies of new system and application software to determine impact on operating system; recommend modifications as appropriate.

Marginal Functions:

1. Maintain system software manuals and reference material.
2. Maintain data security and user passwords.
3. Provide technical support to programming staff, PC users and other system users.

4. Perform related duties and responsibilities as required.

QUALIFICATIONS

Knowledge of:

Principles of data processing and database administration.
Data communication networks and their software and hardware components.
Principles and techniques of computer programming in system and application software.
Statistical methods and procedures.

Ability to:

Install, update and maintain system software on a mainframe computer.
Analyze and correct complex system and application problems and errors.
Analyze and develop complex system and application software.
Provide assistance and technical support to others in use of the system and the creation and use of computer software.
Troubleshoot, repair or modify electronic control equipment.
Read, interpret and apply technical publications, manuals and other documents.
Understand and follow oral and written instructions.
Establish and maintain effective working relationships with those contacted in the course of work. Communicate clearly and concisely, both orally and in writing.
Maintain mental capacity which allows for effective interaction and communication with others. Maintain physical condition appropriate to the performance of assigned duties and responsibilities which may include the following:

Walking or standing for long periods of time
Operating assigned equipment.

Maintain effective audio-visual discrimination and perception needed for:

Making observations
Communicating with others
Reading and writing
Operating assigned equipment.

Experience and Training Guidelines

Any combination of experience and training that would likely provide the required knowledge and abilities is qualifying. A typical way to obtain the know/edge and abilities would be:

Experience:

Two years of increasingly responsible systems programming experience.

Training:

Equivalent to an Associate's degree from an accredited college or university with major course work in computer science or a related field.

WORKING CONDITIONS

Environmental Conditions:

Office environment; exposure to computer screens; electrical energy.

Physical Conditions:

Essential and marginal functions may require maintaining physical condition necessary for light lifting; bending, stooping, kneeling, crawling; sitting for prolonged periods of time.

SENIOR TRAFFIC CONTROL SYSTEM TECHNICIAN

Class specifications are intended to present a descriptive list of the range of duties performed by employees in the class. Specifications are not intended to reflect all duties performed within the job.

DEFINITION

To lead, oversee, and participate in the more complex and difficult work of staff responsible for data communication equipment for the Las Vegas Area Computer Traffic System; to perform skilled electronic work in the repair and maintenance of traffic signal control devices and other solid state electronic equipment; and to assist in traffic pattern development to facilitate traffic progression.

DISTINGUISHING CHARACTERISTICS

This is the advanced journey level class in the Traffic Control Systems Technician series. Positions at this level are distinguished from other classes with in the series by the level of responsibility assumed and the complexity of duties assigned. Employees perform the most difficult and responsible types of duties assigned to classes within this series. Employees at this level are required to be fully trained in all procedures related to assigned area of responsibility.

SUPERVISION RECEIVED AND EXERCISED

Receives general supervision from higher level staff.

Exercises functional and technical supervision over technical staff.

ESSENTIAL AND MARGINAL FUNCTION STATEMENTS- Essential and other important responsibilities and duties may include, but are not limited to, the following:.

Essential Functions;

1. Lead, plan, train, and review the work of staff responsible for data communication equipment and the Traffic Control Center.
2. Plan, direct and participate in the activities of the Las Vegas Area Computer Traffic System Section.
3. Perform complex duties to repair and maintain communication equipment, to include component level repair of modems, cabling, disk drives, printers, plotters, and microwave communication.
4. Verify integrity and location of communication cables throughout the Las Vegas Valley.
5. Develop and maintain traffic signal progression patterns; assist operating engineer in

implementing traffic control patterns to facilitate speed and safety.

6. Notify the field maintenance personnel of the jurisdictional operators of equipment malfunctions in their areas.
7. Run diagnostic software during the periodic maintenance of the mainframe traffic control system computer; maintain computer **and** its component parts.
8. Diagnose and repair problems with signalized intersections under computer control; rewire and adapt signalized intersections for computer control.

Marginal Functions:

1. Document work on Las Vegas Are Computer Traffic System.
2. Perform related duties and responsibilities as required.

QUALIFICATIONS

Knowledge of:

Principles and practices of electronic theory, use, and operation of various scopes, meters, and counters.
Principles and practices of data communications.
Principles and practices of computer operations.
Interpretation of design schematics, site plans, maps, and engineering drawings.
Pertinent Federal, State, and local codes, laws, and regulations regarding electronics.
Basic mathematical principles.
Tools, equipment, and methods used in installing, maintaining, and repairing electronics solid state traffic signals and other equipment.
Principles and practices of the use of diagnostic and utility software to find problems and repair system equipment.
Principles and practices of traffic control guidelines both state and local.

Ability to:

Learn to troubleshoot and repair data communications equipment and cable.
Operate advanced electronic test equipment.
Wire and connect cables necessary for operation of signalized intersections.
Install and remove electronic devices.
Understand follow oral and written instructions.
Establish and maintain effective working relationships with those contacted in the course of work.
Communicate clearly and writing.
Perform repairs from a hydraulic ladder or other elevating device.
Troubleshoot and repair data communication equipment and cable.
Operate and maintain microwave communication equipment.

Experience and Training Guidelines

Any combination of experience and training that would likely provide the required knowledge and abilities is qualifying. A typical way to obtain the knowledge and abilities *would be:*

Experinence

Three years of increasingly responsible experience in traffic control systems.

Training:

Equivalent to graduation from high school. Additional specialized training in electronics or related field.

License or Certificate

Possession of, or ability to obtain, an appropriate valid driver's license.

WORKING CONDITIONS

Environmental Conditions:

Office and shop environment; travel from site to site; exposure to electrical energy, high voltage computer screens, heat, cold, noise, dust, fumes, inclement weather conditions; work at heights on ladders or other elevating device.

Physical Conditions:

Essential and marginal functions may require maintaining physical condition necessary for moderate or light lifting; walking, standing, stooping, kneeling, and climbing; standing for prolonged period of time; operating motorized equipment and vehicles; and the ability to distinguish color.

TRAFFIC CONTROL SYSTEM TECHNICIAN I
TRAFFIC CONTROL SYSTEM TECHNICIAN II

Class specifications are intended to present a descriptive list of the range of duties performed by employees in the class.
Specifications are not intended to reflect all duties performed within the job.

DEFINITION

To operate, maintain data communication equipment for the Las Vegas Area Computer Traffic System; to perform skilled electronic work in the repair and maintenance of traffic signal control devices and other solid state electronic equipment; and to assist in traffic pattern development to facilitate traffic progression.

DISTINGUISHING CHARACTERISTICS

Traffic- This is the entry level class in the Traffic Control System Technician series. This class is distinguished from the Traffic Control Systems Technician II by the level of experience required for the performance of the tasks and duties assigned to positions within the series. Since this class is typically used as a training class, employees may have only limited or no directly related work experience.

Traffic- This is the full journey level class within the Traffic Control System Technician series. Employees within this class are distinguished from the Traffic Control System Technician I by level of experience required to perform the full range of duties as assigned. Employees at this level receive only occasional instruction or assistance as new or unusual situations arise, and are fully aware of the operating procedures and policies of the work unit. Positions in this class are flexibly staffed and are normally filled by advancement from the I level, or when filled from the outside, have prior experience.

SUPERVISION RECEIVED AND EXERCISED

Traffic Control System Technician I
Receives direct supervision from higher level division staff.

Traffic Control System Technician II
Receives general supervision from the Traffic Control System Manager.

ESSENTIAL AND MARGINAL FUNCTION STATEMENT *-Essential and other important responsibilities and duties may include, but are not limited to, the following:*

Essential Functions:

1. Operate and monitor the Traffic Control Center during designated operational hours.
2. Repair and maintain communication equipment, to include component level repair of modems, cabling, disk drives, printers, plotters, and microwave communication equipment.
3. Verify integrity and location of communication cables throughout the Las Vegas Valley.
4. Develop and maintain traffic signal progression patterns; assist operating engineer in implementing traffic control patterns to facilitate speed and safety.
5. Notify the field maintenance personnel of the jurisdictional operators of equipment malfunctions in their areas.
6. Run diagnostic software during the periodic maintenance of the mainframe traffic control system computer; maintain computer and its component parts.
7. Diagnose and repair problems with signalized intersections under computer control; rewire and adapt signalized intersections for computer control.

Marginal Functions:

1. Maintain ADC map display.
2. Operate and maintain automatic telephone dialing machine.
3. Track, order, and stock electronic replacement parts.
4. Perform related duties and responsibilities as required.

QUALIFICATIONS

Traffic Control System Technician I
Knowledge of;

Principles and practices of electronic theory, use, and operation of various scopes, meters, and counters.
Principles and practices of data communications.
Principles and practices of computer operations.
Interpretation of design schematics, site plans, maps, and engineering drawings.
Pertinent Federal, State, and local codes, laws, and regulations regarding, electronics. Basic mathematic principles.
Tools, equipment, practices and methods used in installing, maintaining and repairing, electronic solid state traffic signals and associated equipment.

Ability to:

Learn to troubleshoot and repair data communication equipment and cable.
Operate advanced electronic test equipment.

Wire and connect cables necessary for operation of signalized intersections.
Install and remove electronic devices.
Understand and follows oral and written instructions.
Establish and maintain effective working relationships with those contacted in the course of work.
Communicate clearly and concisely.
Perform repairs from a hydraulic ladder or other elevating device.

Experience and Training Guidelines

Any combination of experience and training that would likely provide the required knowledge and abilities is qualifying. *A* typical way *to* obtain the knowledge and abilities would be:

Experience:

No experience is required. One year of electronics experience is highly desirable.

Training:

Equivalent to the completion of the twelfth grade. Additional specialized training in electronics or a related field is required.

License or Certificate

Possession of an appropriate valid driver's license.

Traffic Control System Technician II

In addition to the qualifications for the Traffic Control System Technician I:

Knowledge of:

Principles and practices of the use of diagnostic and utility software to find problems and repair system equipment.
Principles and practices of traffic control guidelines both state and local.

Ability to:

Troubleshoot and repair data communication equipment and cable.
Operate and maintain microwave communication equipment.

Experience and Training Guidelines

Any combination of experience and training that would likely provide the required knowledge and abilities is qualifying. A typical way to obtain the knowledge and abilities would be:

Experience

Two years of increasingly responsible experience in electronics.

Training:

Equivalent to the completion of the twelfth grade. electronics is required. Addition specialized training in electronics is required.

License or Certificate

Possession of, or ability to obtain, an appropriate, valid driver's license,

WORKING CONDITIONS

Environmental Conditions:

Office and field environment; travel from site to site; exposure to electrical energy, high voltage, computer screens, heat, cold, noise, dust, fumes, inclement weather conditions; work at heights on ladders or other elevating device.

Physical Conditions:

Essential and marginal functions may require maintaining physical condition necessary for moderate or light lifting; bending, stooping, kneeling, climbing; standing for prolonged periods of time; operating motorized equipment and vehicles; and the ability to distinguish color.

ENGINEERING TECHNICIAN II

Class specifications are intended to present a descriptive list of the range of duties performed by employees in the class. Specifications are not intended to reflect all duties performed within the job.

DEFINITION

To perform a variety of complex technical civil engineering work including traffic, electrical, survey, design and drafting work; to perform duties involved in field survey, engineering, and construction inspection activities; and to provide assistance to professional level engineering staff.

DISTINGUISHING CHARACTERISTICS

This is the full journey level class within the Engineering Technician series. Employees within this class are distinguished from the Engineering Technician I by the performance of the full range of duties as assigned including handling all aspects of assigned counter, design and drafting work. Employees at this level receive only occasional instruction or assistance as new or unusual situations arise, and are fully aware of the operating procedures and policies of the work unit.

SUPERVISION RECEIVED AND EXERCISED

Receives general supervision from higher level engineering staff.

ESSENTIAL AND MARGINAL FUNCTION STATEMENT -*Essential and other important responsibilities and duties may include, but are not limited to, the following:*

Essential Functions:

1. Perform skilled drafting for engineering projects; assist engineering staff in preparing engineering designs, drawings, specifications and project estimates.
2. Participate in a variety of engineering studies; conduct research, analyze complex technical data; read and interpret engineering data; write reports and present findings.
3. Perform complex calculations to determine angles, elevations and volume; perform cost estimates; calculate fees and project costs; submit billing information.
4. Investigate public complaints; make recommendations based on findings to resolve problems; interpret federal, state and local regulations for the public.

When assigned to Traffic Section:

1. Draft and design traffic signal, road markings and traffic signal plans; initiate paperwork to revise standard drawings; update traffic plans and drawings.
2. Perform studies to determine locations of traffic control devices; monitor traffic flow; identify hazardous locations; investigate traffic accidents; make written recommendations for changes to existing traffic control devices; explain information to citizens and committee groups.
3. Maintain records on labor and material costs for traffic construction projects; calculate and coordinate billing transactions with Finance; maintain records on accidents and construction parking, permits.
4. Prepare intersection status reports for the signals in specific locations of local area; update traffic computer database; monitor signal systems computer console; inform other jurisdictions of incidents or concerns.

When assigned to Planning Section:

1. Receive design drawings, maps and plans; review for accuracy and compliance; interpret, catalogue, index and assign file numbers; maintain engineering drawing filing and retrieval system; maintain cross reference card system; update and revise drawings, maps and plans.
2. Research information requested by engineering firms, contractors, developers, government agencies and general public; provide information and requested data; reproduce design drawings upon request; maintain information for billing purposes, collect fees for reproductions.
3. Perform civil engineering research from Department's engineering plans library; provide technical information for engineering staff, produce documents for project committee groups and public meetings.

When assigned to Design Section:

1. Draft and design plans; create designs and drawings for various projects; post right-of-way, vacations, casements, annexations in district books; update and revise information; apply field notes and survey information to draft and sketch material for projects.
2. Write and proofread legal descriptions; check and approve plans and drawings; review study submittals; make written recommendations and reports.
3. Research, investigate and analyze complex problems in preparation for construction projects, land titles, and property acquisitions.
4. Provide information to the public, contractors and consultants relative to public works construction projects.

Essential Functions:

When assigned to Survey Section:

1. Set up and operate survey equipment including theodolite, engineering levels, transits, electronic measuring devices and related equipment used to measure distances and perform mathematical calculations; undertake a variety of detailed engineering surveys.
2. Set survey monuments for section corners, reference points and property corners; set precision leveling benchmarks; set elevations for sewer lines, road grades, curbs and gutters.
3. Make notations of surveying observations in field notebook; review and update information in field note records; read and interpret survey information; maintain files of survey data and field notes.

When assigned to Electrical Section:

1. Create streetlighting and electrical systems drawings; update and revise electrical drawing books and records; generate plot plans.
2. Verify existing electrical systems and conditions in the field; assist with line location; provide information for field crews.
3. Read and interpret technical electrical drawings and schematics; make revisions to plans and drawings; maintain files of electrical plans and records.

Marginal Functions;

1. Perform purchasing activities for the division.
2. Perform related duties and responsibilities as required.

QUALIFICATIONS

Knowledge of:

Techniques and practices of land surveying, electrical, traffic, design or planning engineering.
Trigonometry as applied to the computation of angles, areas, distances, and traverses.
Design and construction theory and engineering design standards.
Terminology, methods, practices, and techniques of drafting.
Materials, methods, and techniques of modern construction.
Methods and techniques of construction inspection.
Engineering maps and records.
Construction plans and specifications.
Modern office procedures, methods, and computer equipment.
Applicable laws, regulations, codes, department policies, governing assigned engineering duties.

Ability to:

Interpret and apply state and local policies, procedures, laws, codes, and regulations.
Direct the work of an assigned survey crew.
Reduce, interpret, and apply field notes in the performance of drafting, engineering, and survey duties.
Compile rough technical data and prepare statistical and narrative reports from field studies.
Perform civil engineering design and drafting work.
Understand and interpret engineering plans and specifications.
Deal firmly and tactfully with contractors, engineers, and property owners.
Prepare accurate engineering records.
Use algebraic formulas, trigonometry tables and statistical mathematics to accomplish the level of work described herein.
Communicate clearly and concisely, both orally and in writing.
Establish and maintain effective working relationships with those contacted in the course of work.
Maintain mental capacity which allows for effective interaction and communication with others.
Maintain effective audio-visual discrimination and perception needed for:

- Making observations
- Communicating with others
- Reading and writing
- Operating assigned equipment

Experience and Training Guidelines

Any combination of experience and training that would *likely provide the* required knowledge *and* abilities is qualifying. A typical way to obtain *the* knowledge and abilities *would be:*

Experience:

Two years of increasingly responsible technical engineering experience in the areas of public works project drafting, planning, traffic electrical and/or survey.

Training

Equivalent to an Associates degree from an accredited college with major course work in engineering or courses related to assigned areas of responsibility.

WORKING CONDITIONS

Environmental Conditions:

Field and office environment; exposure to computer screens and inclement weather conditions.

Phvsical Conditions:

Essential and marginal functions may require maintaining physical condition necessary for sitting, standing, and walking for prolonged periods of time.