TRAFFIC COMMITTEE

TRAFFIC SIGNAL SYNCHRONIZATION, OPERATION AND MAINTENANCE PROGRAM

FOR THE CITIES AND OTHER AGENCIES
IN LOS ANGELES COUNTY

FINAL REPORT

May 31, 1990

Presented by:

JHK & Associates
Kaku Associates

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1. INTRODUCTION

This document constitutes the Final Report for Phase 1 of the Traffic Reduction and Free Flow Inter-agency Committee's (TRAFFIC's) study on improving traffic signal synchronization, operation and maintenance in the County of Los Angeles.

This section presents a background to the study by describing the TRAFFIC committee's goals and objectives regarding the study.

Section 2 of the report examines the study's findings on the organizational issues and recommends a countywide organization configured on a regional basis. It also introduces the concept of a central traffic signal secretariat charged with funding control and providing a central support service to the agencies in the County.

Section 3 presents a cost analysis of the two alternatives remaining following the preliminary assessment of alternatives. Both capital implementation and operational/maintenance costs are summarized per region and program level costs are established.

Section 4 discusses the important issue of incentives and recommends actions to be taken to solicit support for the countywide program.

Section 5 presents a summary of the Phase 1 findings and recommendations.

1.1 THE TRAFFIC REDUCTION AND FREE FLOW INTERAGENCY COMMITTEE (TRAFFIC)

In March 1988, the Traffic Reduction and Free Flow Interagency Committee (TRAFFIC) was created to identify and implement programs, strategies and measures to relieve congestion and improve traffic flow in Los Angeles County and its cities. TRAFFIC consists of enforcement, transportation and other public agencies, as well as the private sector, committed to the three E's of transportation: Enforcement, Engineering and Education. TRAFFIC is actively pursuing various programs recommended by the subcommittees and spearheading Countywide efforts to better manage traffic flow and reduce congestion.

TRAFFIC has the following goals:

- o Coordinate Enforcement, Transportation and Education Efforts
- o Disseminate Information Provided by Enforcement, the Media, and others
- o Optimize and Integrate Transportation Facilities

- o Rigorous Enforcement and Emphasis on Congestion Relief to Improve Traffic Flow and Safety
- o Educate the Public to Effect Peak-Hour Travel Changes
- o Improve the Coordination, Efficiency, and Safety of Travel Modes
- o Improve Peak-Hour Traffic Flow
- o Reduce the Number of Peak-Hour Trips

To attain these goals, a subcommittee is implementing the programs and strategies under the following major headings:

Enforcement

1. Emergency Actions with Congestion Relief
2. Expedite Truck Movements
3. Information Services
4. Coordination with Involved Agencies

Engineering

1. Capacity Improvements
2. Traffic Flow Improvements
3. Peak-Hour Trip Reduction

Education

1. Education and Communication for Peak-Hour Reduction and Energy Conservation
2. Education of Traffic and Parking Laws
3. Travel Assistance

1.2 COUNTYWIDE TRAFFIC SIGNAL SYNCHRONIZATION, OPERATION AND MAINTENANCE PROGRAM

1.2.1 - Inception of the Program

Traffic signal synchronization programs are effective in improving signal coordination and reducing traffic congestion. The benefits of such programs accrue only as long as the signal systems are properly operated and maintained by all public agencies. Further, there is a need to bring together the various individual traffic signal synchronization efforts into a combined Countywide effort to ensure the effective operation and maintenance of as many traffic signals as possible. There are roughly 10,000 traffic signals Countywide. With all the cities, the County and State operating and maintaining their signals using different criteria and priorities, there are bound to be gradations of levels of operation and maintenance experienced by motorists travelling along an arterial highway and passing through several cities. This innovative TRAFFIC program was conceived by the Engineering Subcommittee to get as many jurisdictions as possible involved to maximize coordination and achieve the highest possible level of operation and maintenance Countywide.

Consequently, TRAFFIC recommended that a consultant with specialized expertise in traffic signal systems be retained to analyze and study various alternatives and plan the development of this program. Subsequently, JHK & Associates was retained under contract to prepare a comprehensive proposal that would address both the institutional and technical issues of operation and maintenance of a Countywide Traffic Signal Synchronization, Operation and Maintenance Program. Under this program, as many as possible of the traffic signals Countywide could be operated and maintained using area-wide criteria.

1.2.2 - Goals of the Program

The goal of this program is to improve traffic flow and mobility, especially on arterial highways, by operating and maintaining traffic signals Countywide at optimal efficiency. This would greatly benefit the motoring public, result in uniform signal control, provide continuity across city boundaries, improve air quality, and reduce travel time, delay and fuel consumption.

The objective of the Phase One Pre-Design Study was to prepare a comprehensive proposal that would address both the institutional and technical issues of operation and maintenance of a Countywide Traffic Signal Synchronization, Operation and Maintenance Program and develop broad support from the cities, the County and the State.

1.2.3 - Guidelines Developed

The institutional and technical portions of the Phase One study were to include but not be limited to the following tasks:

1.2.3.1 - Task 1

1. To draw on past experiences of such programs, describe known multi-agency traffic signal synchronization, operation and maintenance programs in the area as well as nationwide. Discuss the development of the programs as well as their successes and failures.

2. Identify various possible signal synchronization, operation and maintenance program alternatives, including those identified by TRAFFIC.

3. Evaluate and discuss the advantages and disadvantages of the various alternatives.

4. List and discuss technical aspects, including successes, failures and shortcomings of known similar projects in the area as well as nationwide. This discussion should include but not be limited to the following:

   a. The type of hardware and software used in similar projects.
   b. The availability of hardware and software for use in implementing this type of program as well as spare parts availability for maintenance purposes.
   c. The serviceability of the equipment.
   d. The ability to interface with various traffic signal systems, including radio corrected time based systems and central computer systems.

1.2.3.2 - Task 2

1. Identify and discuss incentives that may be necessary to encourage cities, County and State to participate in this program.

2. Schedule and conduct all necessary group and/or individual meetings, workshops and presentations with TRAFFIC Committee members, the cities, and all other involved agencies and organizations to build a consensus on one or more of the identified alternatives. Identify a contact person within each agency/organization.

1.2.3.3 - Task 3

1. Discuss specific technical issues involved in developing a program for synchronizing, operating and maintaining the traffic signals Countywide. This discussion should include but not be limited to the following:

   a. Public and private sector operation and/or maintenance of the signal system.
   b. A description of how traffic progression across jurisdictional boundaries will be accomplished.
   c. The need for the different types of signal systems based on area needs, signal density and cycle length requirements.

2. Identify and discuss the signal systems currently under design or in operation by all agencies in Los Angeles County. (Note: Type controllers shall be used where agencies currently use them or desire to use them. Also, since WWV/WWVH is being used in the County's Five-Year Traffic Signal Interconnect Program, it shall be used where possible for this program.) This discussion should include but not be limited to the following:

a. The compatibility of the existing system to be incorporated into a Countywide program.
b. The expandability of the existing signal systems.
c. The ability of adjacent signal systems to maintain reasonable traffic progression across jurisdictional boundaries.

3. Discuss provisions for inspection to determine compliance with operation and maintenance agreements.

1.2.3.4 - Task 4

1. Prepare a complete and thorough report to the satisfaction of the Los Angeles County Department of Public Works (DPW), containing the above information as well as the results of the various meetings and workshops. Obtain written documentation to show that a significant number of cities and other involved agencies agree in principle on which alternative(s) is best, and that they are willing to participate. This will enable the DPW to determine if the overall program will be successful.

2. Prepare cost estimates for expenses expected to be incurred and include a time-line schedule for the Phase Two Study of this proposal for the best alternatives.

3. Justify the recommended alternative(s) based on institutional factors, technical aspects and costs.

1.3 RELATED PROGRAMS

The County of Los Angeles already has in place a program to support the implementation of coordination at intersections using a time synchronization technique. This is the Five-Year Interconnect Program based on the use of WWV radio broadcasts.

WWV is a short wave radio signal broadcast by the Department of Commerce, National Institute of Standards and Technology from Fort Collins, Colorado.

The signal is received by a special radio receiver located at each intersection and decoded to provide information that the Type 170 traffic signal controller can use to change from free to system operation, change split(s) and cycle lengths; and it eliminates yearly maintenance by programming for special events/holidays for the next 20 years.

The program software to provide these functions was written by Los Angeles County staff. The program provides coordination of full traffic actuated signals while still maintaining the benefits of full traffic actuation when in an interconnected system operation; i.e. progression on the arterial street is maintained by heavy arterial traffic extending the green band beyond the minimum, while delay on the side street is reduced to the minimum in the absence of arterial traffic.

WWV radio receivers are available for most current generation NEMA controllers so that mixed systems of Type 170 controllers and NEMA controllers can be progressed on a common cycle system.

Should a city wish to take part in the program, then shared funding is available provide the City enters into an agreement with the County. A summary of this agreement is presented in Exhibit 1-1.

JHK was asked to take this program into account when carrying out the study.

1.4. CONSULTANT OBJECTIVITY

Part of the services which JHK & Associates provides as a Traffic and Transportation consultant is in the field of traffic control systems. Such services include feasibility studies, system integration and software development.

As part of this study involved the analysis of several system approaches to the solution of traffic signal management problems in Los Angeles County, JHK has been requested to confirm the consultant's objectivity and clarify any possible conflict of interest.

Primarily it should be noted that none of the recommendations of the study refer to any specific equipment solution other than supporting the County's current coordination program in which JHK has no financial or business interest.

The systems comparison identifies the issues involved in system selection and recommends that each city be assessed individually to establish which of the technical options would be most applicable. There is no bias as to system recommendation as there is no specific system recommendation.

The draft of this Final Report has been extensively reviewed by County staff and all of their comments addressed, specifically those relating to the system alternatives assessment in order to produce an objective, unbiased analysis.

Finally, none of the work carried out in the study, nor the recommendations made by JHK give JHK any commercial advantage over other companies save any associated with having carried out the Phase I study.

Exhibit 1-1

Summary of Features of the Interagency Agreement Associated with the County Interconnect Program

Agency 1: A City

Agency 2: County of Los Angeles

Responsibilities:

Agency 1 - Design/Partially Fund Project

Agency 2 - Construct/Partially Fund Project/Maintain

Liability:

"Mirrored" Held Harmless Provision

Synchronization:

Stated in Pre-amble to agreement
Specific Clause: "... all signals must remain synchronized".

Operations:

No change in traffic signal timings without mutual agreement

Maintenance:

Reference to Traffic Signal Maintenance Agreement 44790

Costs:

50/50 Agency 1/Agency 2

2. ORGANIZATIONAL ISSUES

2.1 PROGRAM ALTERNATIVES

2.1.1 - Review

As part of the work carried out under Phase 1 of the study, a number of program alternatives were devised and presented in Working Paper 1 Part 1. Exhibits 2-1 through 2-12 present the various alternatives analyzed; these are summarized in Exhibit 2-13. A preliminary assessment of alternatives was presented in Working Paper 1 Part 3 which reduced the number of organizational options for the program to 4. These are summarized in Exhibit 2-14. These were further refined as presented in Working Paper 2 Part 1 leaving the two options R2 and R5. The details of the analysis are given below.

It should be noted that the summaries differ from those presented originally reflecting comments received via the TRAFFIC staff.

As can be seen, the program alternatives differ in the area of coverage; R2 addressing all intersections in the County, while R5 is confined to intersections on arterials. Other than this geographical difference, the two alternatives are very similar in scope as the agencies and the division of responsibilities between them are the same.

2.1.1.1 - Preliminary Assessment

There are two primary aspects of the alternatives that can be assessed at this point. The first deals with the extent of installing an area-wide system and the second deals with the maintenance requirements.

There is strong evidence that a single, centrally operated control system is not feasible. The major cities that have or are installing central control systems are unwilling to turn these over to another agency for day to day control. Likewise, cities with existing systems do not feel that they could justify significant replacement of equipment that might be needed to accommodate a specific central system, especially when they feel that there are other options available for meeting the basic goals without moving completely to one system.

Further, the cities that are actively operating or installing systems do not appear willing to "give up" operational responsibility. At the same time, these agencies do appear willing to "cooperate" in an effort to meet the goals of improved countywide coordination. Several cities specifically indicated a willingness to provide system control for adjacent jurisdictions and to develop signal operations plans that made city boundaries "transparent" to the motorists. These included the City of Los Angeles, Long Beach, and Pasadena.

From the information gathered, then, any alternative which requires complete central control and operation should be eliminated from further consideration. In the strictest sense, this eliminates Alternatives W1, W4, R1, and R4 from the final alternatives. It is noted, however, that the goal of area-wide coordination can be achieved by coordinating adjacent "systems" without implying direct central control. This could be accomplished by simply using the WWV time base for each system or intersection and then developing agreements regarding the operation of the adjacent systems.

The same basic conclusion is reached when viewing the issue from the perspective of maintenance. Whether fully justified or not, several local agencies feel strongly that they must have direct responsibility for maintenance of signals in their city. The sole issue appears to be the timeliness of response and direct accountability. It is likely that this could be changed over time if a highly responsive central agency were in place, however developing a consensus on this appears unlikely in the near term. This re-enforces the assessment that a single central agency form of operation and maintenance is not feasible, supporting the elimination of Alternatives W1, W4, R1 and R4.

Given this basic assessment, all of the "W" alternatives (area-wide) might be seen as questionable. This is directly dependent on how the area-wide is defined. As noted above, it is practical to envision features which make area-wide coordination possible without requiring a true central system. This simply implies a method for keeping systems coordinated and the example of WWV technology, or one where a direct intertie between systems is provided, are appropriate. For purposes of the initial assessment, it is recommended that all of the "W" alternatives be eliminated but that the specific feature of coordinating the "R" or regional alternatives be considered as part of the evaluation of those alternatives.

This leads to the conclusion that specific alternatives should be configured around the generic features of alternatives R2, R3, R5, and R6. These are the regional alternatives which would consider, all signals, all boundary signals, all arterial signals, or arterial boundary signals, or a combination thereof.

Independent of the geographical variations in the alternatives, a major difference is in the role of the central agency. In R2 and R5, the central agency plays an active role in operations and maintenance of some equipment, in R3 and R6 a central agency has essentially no such role.

The four remaining alternatives are distinguished by the extent to which the program would be applicable i.e. for all intersections, all intersections at the boundaries of jurisdictions, intersections on arterials and intersections on arterials at the boundaries of jurisdictions.

In carrying out a review of the equipment currently in place, it became apparent that the two options, which only consider intersections at jurisdictional boundaries, are not practicable for the following reasons:

a. Such intersections cannot be treated in isolation for coordination purposes, especially when they are located on arterials.

b. In many cases, they already form part of a coordinated system and so extension of coverage to the rest of the system would be necessary in any event.

In addition to this, there was considerable emphasis given to the coordination of arterials during the various Focus Group meetings to the extent that improvement in arterial operations was seen as a program "minimum scope". Consideration of only boundary intersections would not provide the degree of coordination demanded by a program concentrated on operating an arterial network.

Given the above, the geographical alternatives were reduced to those considering all intersections as part of the program, and the coverage of arterials only (alternatives R2 and R5 respectively).

2.1.2 - Key Issues

In order to gather views from the large number of agencies involved in an efficient and timely manner, a series of meetings, or Focus Groups, were organized throughout the County. Each meeting comprised approximately 10 City representatives, with occasional representation by Caltrans, Los Angeles County DPW and TRAFFIC staff. The meetings were hosted by one of the cities located approximately central to the group of cities involved. The consultant chaired the meetings, prepared the agenda and presentation materials and wrote-up summaries of the comments received.

The Focus Group meetings proved invaluable in assimilating information on existing conditions and problem areas in the County. The views expressed were taken into account when carrying out the preliminary assessment and formulating the proposed organizational approach. The following sections summarize the results of these meetings.

The views presented below are those which are considered to be most relevant in relation to the particular study area of either Synchronization, Operations or Maintenance. They should not, however, be accepted as being applicable automatically to all cities within the County; they were, however, the most influential views in determining the applicability of the alternatives.

PROGRAM ALTERNATIVES SUMMARY SHEET

ALTERNATIVE ID. : W1

CHARACTERISTICS : Area Wide: Yes | Regional : | Arterial Only : No

RESPONSIBILITIES :	Central Agency	Choice	State/ County/City
Operations and Maintenace	All	No	None

ADVANTAGES

1. Emphasis on coordination across jurisdictional boundaries.
2. Uniform maintenance levels established.
3. Would promote a wide-area solution to moving traffic - ie. area needs dominate over regional and local achieving a County-wide optimum
4. Cities have the incentive of being able to relinquish some or all liability to the central agency.
5. Eventual uniformity of traffic signal devices (cost advantages through central agency bulk purchasing).

DISADVANTAGES

1. Does not recognize that in some cases, the cities are best suited to operate and maintain signals.
2. Danger of being perceived as insensitive to local needs.
3. Perception that cities must "give up control".
4. Does nothing to promote City/State/County cooperation.
5. Accommodation of regional differences in equipment.

OTHER CONSIDERATIONS

1. A major problem will be avoiding the central agency becoming remote from and insensitive to/unaware of local issues.
2. This alternative necessitates some form of central control system to support day-to-day operations and maintenance.
3. Operational and maintenance improvements gained by achieving uniform maintenance levels may be overshadowed by a degradation in response to problems/faults in some areas.

Exhibit 2-1

PROGRAM ALTERNATIVES SUMMARY SHEET

ALTERNATIVE ID. : W2

CHARACTERISTICS : Area Wide: Yes | Regional : | Arterial Only : No

RESPONSIBILITIES :	Central Agency	Choice	State/ County/City
Operations and Maintenace	Some	Yes	Some

ADVANTAGES

1. City pro-active in defining operations and maintenance choices.
2. Promotes City/State/County cooperation.
3. More sensitive to local needs than W1.
4. Takes advantage of local resources/expertise.

DISADVANTAGES

1. County-wide operational and maintenance standards difficult to enforce/police.
2. Introduction of further jurisdictional boundaries (Central/City, Central/County, Central/State).
3. Area-wide control policies/strategies more difficult to implement than W1.
4. Accommodation of regional differences in equipment.

OTHER CONSIDERATIONS

1. County-wide operational and maintenance criteria need to be established, but are harder to police than in alternative W1.
2. Practical implementation dependent upon legal status of city divesting liability by agreement.
3. The central agency will only be a viable maintenance/operations option if it proves responsive and cost effective.
4. Arbitration of Area-wide/local operational conflicts is essential.
5. Some form of central control system needed by the central agency.

Exhibit 2-2

PROGRAM ALTERNATIVES SUMMARY SHEET

ALTERNATIVE ID. : W3

CHARACTERISTICS : Area Wide Boundaries Only Regional : Arterial Only : No

RESPONSIBILITIES :	Central Agency	Choice	State/ County/City
Operations and Maintenace	None	NA	All

ADVANTAGES

1. Emphasis on coordination at city boundaries.
2. Local autonomy protected.

DISADVANTAGES

1. County-wide operational and maintenance programs difficult to enforce/police.
2. Area-wide traffic control strategies more difficult to implement than W1 and W2.
3. Local autonomy protected.
4. Accommodation of regional differences in equipment.

OTHER CONSIDERATIONS

1. The central agency's role is to promote maintenance and operational agreements between the State, County and individual cities.
2. County-wide operational and maintenance criteria need to be established, but are more difficult to police than in alternatives W1 and W2.

Exhibit 2-3

PROGRAM ALTERNATIVES SUMMARY SHEET

ALTERNATIVE ID. : W4

CHARACTERISTICS : Area Wide: Yes | Regional : | Arterial Only : Yes

RESPONSIBILITIES :	Central Agency	Choice	State/ County/City
Operations and Maintenace	All	No	None

ADVANTAGES

1. Area-wide operations and maintenance standards applied on major through routes.
2. Favors commuter traffic in an "arterial network".
3. Relinquishing of some liability by cities.
4. Signal synchronization would be provided for jurisdictions currently having none.

DISADVANTAGES

1. Danger of perceived lack of sensitivity to local needs.
2. Perception that cities must "give up control".
3. Introduction of further jurisdictional boundaries (Central/City, Central/State).
4. Does not recognize local resources/expertise.
5. Does nothing to promote City/State/County cooperation.
6. Accommodation of regional differences in equipment.

OTHER CONSIDERATIONS

1. A major problem will be avoiding the central agency becoming remote from and insensitive to/ unaware of local issues.
2. This alternative necessitates some form of central control system to support day-to-day operations and maintenance.
3. Operational and maintenance improvements gained by achieving uniform maintenance levels may be overshadowed by a degradation in response to problems/faults in some areas.
4. A central system would be on a smaller scale than in W1, but complexity of interfaces with other systems (e.g. ATSAC) increases.

Exhibit 2-4

PROGRAM ALTERNATIVES SUMMARY SHEET

ALTERNATIVE ID. : W5			
CHARACTERISTICS : Area Wide Yes	Regional :	Arterial Only : Yes	
RESPONSIBILITIES :	Central Agency	Choice	State/ County/City
Operations and Maintenace	Some	Yes	Some

ADVANTAGES

1. City pro-active in defining operations and maintenance choices.
2. Promotes City/State/County cooperation.
3. More sensitive to local needs than W4.
4. Takes advantage of local resources/expertise.
5. Favors commuter traffic in an "arterial network".
6. Area-wide operations and maintenance standards applied on through routes.

DISADVANTAGES

1. County-wide operational and maintenance standards difficult to enforce/police.
2. Introduction of further jurisdictional boundaries (Central/City, Central/County, Central/State).
3. Area-wide control policies/strategies more difficult to implement than W4.
4. Accommodation of regional differences in equipment.

OTHER CONSIDERATIONS

1. County-wide operational and maintenance criteria need to be established, but are harder to police than in alternative W4.
2. Practical implementation dependent upon legal status of city divesting liability by agreement.
3. The central agency will only be a viable maintenance/operations option if it proves responsive and cost effective.
4. Arbitration of Area-wide/local operational conflicts is essential.
5. A central system would be on a smaller scale than in W4, but complexity of interfaces with systems (e.g. ATSAC) increases.

Exhibit 2-5

PROGRAM ALTERNATIVES SUMMARY SHEET

ALTERNATIVE ID. : W6			
CHARACTERISTICS : Area Wide Boundaries Only	Regional :	Arterial Only : Yes	
RESPONSIBILITIES :	Central Agency	Choice	State/ County/City
Operations and Maintenace	None	NA	All

ADVANTAGES

1. Emphasis on coordination of arterials at City boundaries.
2. Local autonomy protected.

DISADVANTAGES

1. County-wide operational and maintenance programs difficult to enforce/police.
2. Area-wide traffic control policies/strategies difficult to implement than W4 and W5.
3. Local autonomy protected.

OTHER CONSIDERATIONS

1. The central agency's role is to promote maintenance and operational agreements between the State, County and individual cities.
2. County-wide operational and maintenance criteria need to be established, but are more difficult to police than in alternatives W4 and W5.

Exhibit 2-6

PROGRAM ALTERNATIVES SUMMARY SHEET

ALTERNATIVE ID. : R1			
CHARACTERISTICS : Area Wide :	Regional : Yes	Arterial Only : No	
RESPONSIBILITIES :	Central Agency	Choice	State/ County/City
Operations and Maintenace	Yes	No	None

ADVANTAGES

1. Takes into account Regional differences (both in terms of control equipment and traffic).
2. Uniform maintenance levels established.
3. Cities would have the incentive of being able to relinquish liability to the central agency.
4. Establishment of Area-wide policies through Regional approach.

DISADVANTAGES

1. Does not recognize that in same cases, the cities are best suited to operate and maintain signals.
2. Danger of being perceived as insensitive to local needs.
3. Perception that cities must "give up control".
4. Does nothing to promote City/State/County cooperation.
5. Regional boundary coordination a potential problem.
6. Dissimilar Regional centers.

OTHER CONSIDERATIONS

1. Regional Centers would be formed rather than one large central system.
2. A major problem will be avoiding the Regional agency becoming insensitive to/unaware of local issues.
3. The form of regional control equipment will vary dependent upon current equipment.
4. Operational and maintenance improvements gained by achieving uniform maintenance levels may be overshadowed by a degradation in response to problems/faults in some areas.

Exhibit 2–7

PROGRAM ALTERNATIVES SUMMARY SHEET

ALTERNATIVE ID. : R2

CHARACTERISTICS : **Area Wide :** | **Regional :** Yes | **Arterial Only :** No

RESPONSIBILITIES :	Central Agency	Choice	State/ County/City
Operations and Maintenace	Some	Yes	Some

ADVANTAGES

1. City pro-active in defining operations and maintenance choices.
2. Promotes City/State/County cooperation.
3. Takes into account Regional differences (both in terms of control equipment and traffic).
4. More sensitive to local needs than R1.
5. Takes advantage of local resources/expertise.

DISADVANTAGES

1. County-wide operational and maintenance standards difficult to enforce/police.
2. Introduction of further jurisdictional boundaries (Central/City, Central/County, Central/State).
3. Area-wide control policies/strategies more difficult to implement than R1.
4. Regional boundary coordination a potential problem.
5. Dissimilar Regional centers in equipment/ operational terms.

OTHER CONSIDERATIONS

1. Regional centers would be formed rather than one large central system.
2. The form of regional control equipment would take into account different equipment.
3. The central agency will only be a viable maintenance/operations option if it proves responsive and cost effective.
4. County-wide operational and maintenance criteria need to be established, but are harder to police than in alternative R1.
5. Practical implementation dependent upon the legal status of cities divesting liabilities by agreement.

Exhibit 2-8

PROGRAM ALTERNATIVES SUMMARY SHEET

ALTERNATIVE ID. : R3			
CHARACTERISTICS : Area Wide :	Regional : Boundaries	Arterial Only : No	
RESPONSIBILITIES :	Central Agency	Choice	State/ County/City
Operations and Maintenace	None	NA	All

ADVANTAGES

1. Emphasis on coordination at City boundaries.
2. Local autonomy protected.

DISADVANTAGES

1. County-wide operational and maintenance programs difficult to enforce/police.
2. Area-wide traffic control strategies more difficult to implement than R1 and R2.
3. Local autonomy protected.
4. Regional differences in terms of traffic control equipment may persist.
5. Regional boundary coordination a potential problem.

OTHER CONSIDERATIONS

1. The central agency's role is to invoke maintenance and operational agreements between the State, County and individual cities.
2. County-wide operational and maintenance criteria need to be established, but are more difficult to police than in alternatives R1 and R2.

Exhibit 2-9

PROGRAM ALTERNATIVES SUMMARY SHEET

ALTERNATIVE ID. : R4

CHARACTERISTICS : Area Wide : Regional : Yes Arterial Only : Yes

RESPONSIBILITIES :	Central Agency	Choice	State/ County/City
Operations and Maintenace	All	No	None

ADVANTAGES

1. Area-wide operations and maintenance standards applied on major through route through a regional approach.
2. Favors commuter traffic in an "arterial network".
3. Relinquishing of liability by cities.
4. Takes into account Regional differences (both in terms of traffic and equipment).

DISADVANTAGES

1. Does not recognize that in some cities, the cities are best suited to operate and maintain signals.
2. Danger of being perceived as insensitive to local needs.
3. Perception that cities must give up control.
4. Does nothing to promote City/State/ County cooperation.
5. Regional boundary coordination a potential problem.
6. Dissimilar Regional centers.
7. Introduction of further jurisdictional boundaries.

OTHER CONSIDERATIONS

1. Regional centers would be formed rather than one large central system.
2. A major problem will be in avoiding the Regional agency becoming insensitive to/ unaware of local needs.
3. The form of regional control equipment will vary dependent upon current equipment.
4. Operational and maintenance agreements gained by achieving uniform maintenance levels may be overshadowed by a degradation in response to problems/faults.

Exhibit 2-10

PROGRAM ALTERNATIVES SUMMARY SHEET

ALTERNATIVE ID. : R5

CHARACTERISTICS : Area Wide : | Regional : Yes | Arterial Only : Yes

RESPONSIBILITIES :	Central Agency	Choice	State/ County/City
Operations and Maintenace	Some	Yes	Some

ADVANTAGES

1. City pro-active in defining operations and maintenance choices.
2. Promotes City/State/County cooperation.
3. More sensitive to local needs than R4.
4. Takes advantage of local resources/expertise.
5. Favors commuter traffic in an "arterial" network".
6. Takes into account regional differences.

DISADVANTAGES

1. County-wide operational and maintenance standards difficult to enforce/police.
2. Introduction of further jurisdictional boundaries (Central/State, Central/City, Central/County).
3. Area-wide control polices/strategies more difficult to implement than R4.
4. Regional boundary coordination potential problem.
5. Dissimilar Regional centers in equipment/ operational terms.

OTHER CONSIDERATIONS

1. Regional centers would be formed rather than one large central system.
2. The form of regional control equipment would take into account current equipment.
3. The central agency will only be a viable maintenance/operations option if it proves responsive and cost effective.
4. Practical implementation may be dependent upon the legal status of cities divesting liability by agreement.

Exhibit 2-11

PROGRAM ALTERNATIVES SUMMARY SHEET

ALTERNATIVE ID. : R6

CHARACTERISTICS : **Area Wide :** **Regional :** Boundaries **Arterial Only :** Yes

RESPONSIBILITIES :	Central Agency	Choice	State/ County/City
Operations and Maintenace	None	NA	All

ADVANTAGES

1. Emphasis on the coordination of arterials at City boundaries.
2. Local autonomy protected.

DISADVANTAGES

1. County-wide operational and maintenance programs difficult to enforce/police.
2. Area-wide control policies/strategies more difficult to implement than R4 and R5.
3. Local autonomy protected.
4. Regional differences in terms of traffic control equipment may persist.
5. Regional boundary coordination a potential problem.

OTHER CONSIDERATIONS

1. The central agency's role is to invoke maintenance and operational agreements between the State, County and individual cities.
2. County-wide operational and maintenance criteria need to be established, but are more difficult to police than in alternatives R4 and R5.

ID	SCOPE OF INFLUENCE		AGENCIES		
	AREA	FACILITY	CENTRAL	CENTRAL OR STATE/COUNTY/CITY	STATE COUNTY/CITY
W1	Wide	All	X		
W2	Wide	All		X	
W3	Wide	Boundaries			X
W4	Wide	Arterial	X		
W5	Wide	Arterial		X	
W6	Wide	Arterial Boundaries			X
R1	Regional	All	X		
R2	Regional	All		X	
R3	Regional	Boundaries			X
R4	Regional	Arterial	X		
R5	Regional	Arterial		X	
R6	Regional	Arterial Boundaries			X

Exhibit 2.13: Definition of Organizational Alternatives

ID	SCOPE OF INFLUENCE		AGENCIES		
	AREA	FACILITY	CENTRAL	CENTRAL OR STATE/COUNTY/CITY	STATE COUNTY/CITY
R2	Regional	All		X	
R3	Regional	Boundaries			X
R5	Regional	Arterial		X	
R6	Regional	Arterial Boundaries			X

Exhibit 2.14: Remaining Organizational Alternatives Following Preliminary Assessment

2.1.2.1 - Synchronization

That there are synchronization problems within the County was agreed to by the majority of the cities. These can be summarized as follows:

1. Inter-city: disruption of coordination at city boundaries. Cities are already cooperating with each other, but in many cases, they do not reach agreement on the correct course of action/timings. In other cases, the cities feel unequipped technically or equipment wise to apply the correct solution to gain coordination.

2. Intra-city: striking a balance between satisfying the demand for arterial progression while keeping side-street delay at a level which is acceptable to the local users.

3. Inter-agency: coordination problems caused by adjacent signals being under the control of different agencies who cannot agree on a course of action/timings. The agency interfaces in question would be City/County, City/Caltrans and County/Caltrans. (This problem is not universal and agencies are working well together in certain areas.)

4. Equipment: the need to establish coordination is agreed, but the equipment solutions present obstacles e.g.:

   o terms of funding for the County's Five-Year Traffic Signal Synchronization Program are not universally acceptable
   o equipment too old, cannot be adapted
   o lack of knowledge of city engineers to assess options
   o uncooperative suppliers (protecting proprietary interests)

Examples of suggested solutions to these problems which are relevant to the assessment of the alternatives are as follows:

1. Inter-City:

   o an independent "expert team" establishes coordination needs
   o a forum for arbitration is established
   o an education program to convince policy makers of the need for inter-city coordination

2. Intra-City:

   o availability of technical expertise in tackling specific

traffic engineering problems
- o improved sensitivity by the County and Caltrans to local impacts of their actions (problem resolution mechanism)

3. Inter-agency:

   - o clear policies are established by the County and Caltrans together with the cities in a participative role
   - o a forum for arbitration is established
   - o improved sensitivity by the County and Caltrans to local impacts of their actions
   - o a forum for inter-agency discussion/action is established

4. Equipment:

   - o availability of independent expertise to advise of equipment options
   - o Countywide standards for the upgrading of traffic control equipment

In brief, it is clear that there is a role for a central agency to play in such areas as:

- o providing independent technical counsel and expertise
- o supporting the development of agency policies through multi-agency contacts
- o providing a forum for problem resolution
- o developing educational/informational programs

The overall need is for means to support cities in their attempts to achieve coordination with inter-agency cooperation as the prime focus area.

2.1.2.2 - Operations

Many of the comments presented above relating to Synchronization are also directly applicable to the area of Operations. As would be expected, where there are difficulties in agreeing between agencies on the need for coordination and/or the methods to be used to achieve it, there also exist day-to-day operational problems.

In addition to those mentioned above, the following problems were also identified:

5. Peak-Hour Flows: With the exception of the more outlying cities, it was presented that the need for the efficient movement of peak-hour volumes should be considered separately. Operationally, the impact of a single-city's action (e.g. in implementing traffic improvements from timing changes to parking provisions) generally has more significant consequences for adjacent cities during peak

conditions than during off-peak periods.

6. Political: the need to get Council support for the implementation of traffic signal improvement programs. Engineers need to have more data to support their case in Council.

7. Aging of Timing Plans: this represents the problem of maintaining timing plans aggravated by staffing and/or funding problems. The problem is principally one of technical resources.

The possible solutions presented above for improving synchronization are also applicable to the area of operations. However, there is a change in emphasis when examining the solutions put forward from an operational viewpoint.

The question of arbitration between agencies is relatively more important in the issue of operations as compared to synchronization because the impact of not being able to develop a specific agreement can be far reaching. Cases were quoted where funding has been lost for major signal improvements due to the inability to find common ground between agencies. Other cases revolve around the refusal of funding due to the arbitrary application of design guidelines with no course of appeal open.

In some cases, the inability to agree or the rigid application of guidelines with perceived disregard for local conditions is felt to be an insensitivity to local issues by a central agency. This view results in the generation of more support for a regional approach to operations - the assumption being that a regional group will be more aware of local conditions and therefore be more sensitive. In addition, cities perceive the ability to contribute more to a regional agency than a "remote" central agency.

With respect to those problems identified specifically for the operational arena, the following solutions were put forward:

5. Peak-hour Flows:

   o development of an arterial network with priority for peak-hour commuter traffic in which regional or central entities have responsibility for peak-hour operations but the arterial operations revert to City control outside of the peaks.

6. Political:

   o development of regional programs to show city councils the need for their support and area-wide consequences of actions, the need for continuing education/information programs.

7. Aging of Timing Plans:

   - o establishment of a locally administered funding for re-timing signals. This would be akin to the current FETSIM program which specifically targets funding for signal timing projects on coordinated systems.
   - o availability of staff/expertise to assist in major re-timing programs or in resolving specific timing problems

There is an apparent desire for a less remote, regional approach to operational problem solving with an emphasis on peak-hour arterial operations in some areas. Again the need is defined as being for support in the form of expertise and guidance.

There is an overriding desire from the majority of cities to maintain some form of direct control of their own signals. The question of putting their signals under the control of a system physically located in an adjoining or remote jurisdiction was acceptable but with the following provisos:

1. that the non-local agency have limited access to the local traffic control equipment via the system for operational needs

2. that the local agency have its own access to its local traffic equipment

3. there be a clear agreement in-place between the agencies involved covering operational and maintenance procedures and responsibilities

With the exception of those cities currently planning to replace an aging central traffic control system, no city with an existing centralized system wants to replace equipment simply to relieve itself of the additional operational and maintenance responsibilities with which owning a system is associated.

No city with central control capability wants to give up that capability and revert to purely on-street equipment.

2.1.2.3 - Maintenance

The options open to the cities in the County of Los Angeles with regard to the maintenance of their traffic control equipment are as follows:

1. maintain their own equipment
2. employ a maintenance contractor
3. employ the County or another city as maintenance contractor

There are various variations possible on these basic options; for example, the sharing of maintenance with another city or the use of a maintenance contractor as a back-up to the city's force. Both of these are used to overcome the problems of staffing, either during vacations or during evenings and weekends. Also, many cities are currently not big enough to justify their own maintenance organization but it is still an option open to them in the future.

In investigating maintenance procedures and practices, it has become apparent that a clear definition of maintenance responsibilities is essential. The goal should be one maintenance organization only in a cabinet. When this is not possible e.g. in the above cases, then good documentation and record keeping of cabinet entries are essential.

There are mixed opinions as to the acceptability of performance of contracted maintenance, either in the form of a private contractor or the County. However, for those cities who have either had, currently have or have experienced city-operated maintenance the summary opinion is that they would not switch to contractor maintenance unless forced to do so by policy makers. This is principally because of the desire to control response time.

City operated maintenance is perceived to be the most responsive in dealing with immediate problems. Some cities measure their response time in minutes (this in a city where the maintenance manager is assessed on response time) whereas it was not uncommon to hear of responses from the other organizations of "a couple of days". The consensus is that this stems from the maintenance organization being directly accountable.

With respect to cost, the opinions are that the maintenance contractor is the least expensive of the three options. However, it is not possible to give cost comparisons between the city- and County-run services. Simple comparisons may prove deceptive; for example, it is likely that the County employs fewer maintenance technicians per intersection than a particular city. However, during the course of the Focus Group Meetings, six cities remarked that the County maintenance response was slow which could be attributed to the lower staffing levels. This must be balanced, however, against those cities who were satisfied with the maintenance provided by the County and had no desire to go to contractor maintenance.

The City of Long Beach Lighting and Signal Maintenance Department was recently asked to carry out a study to justify the maintenance of the traffic signals by the City team given that the cost was perceived to be higher than a signal maintenance contractor. The study apparently justified the continued maintenance by City staff. (JHK was unable to secure a copy of the report due to the sensitive nature of the comments in the document).

As a final comment, it was made clear on several occasions that several cities would not cooperate with a plan that dictated the take-over of maintenance responsibilities from the cities.

In some areas, the agency responsible for the operation of the equipment (timing plan maintenance etc.) is not the agency carrying out the maintenance. There is some concern over the legal liability of this arrangement; if there were to be an accident as a result of the timing the operational agency would have the full responsibility unless it could be shown that the maintenance organization changed the timings.

Whenever operations and maintenance of a traffic signal installation are shared between two or more agencies, it must be clearly defined what the individual agency responsibilities are. This is discussed in more detail in the Review of Practices (Working Paper 1, Part 2) but it is apparent that such agreements are possible and are functioning. The separation of operations and maintenance is thus possible and is given further consideration below.

2.1.3 Operations and Maintenance Divisions

The above section concludes with the remark that a subset of alternatives should also be considered which reflects the practice of dividing the operational and maintenance responsibilities on an intersection between two agencies. In examining current practices, it became apparent that this was already being done successfully within the County.

In practice this should provide no problem if the recommendations stated in Working Paper 1 Part 2 (Review of Current Practices), are followed with respect to the clear definition of responsibilities in operational agreements, together with the rigorous documenting of timing changes.

A disadvantage was identified with both R2 and R5 program options, in that, should a central agency (as yet not in existence) be given some kind of operational role, then this would create an additional inter-jurisdictional boundary. In investigating the question of dividing operational responsibilities, it was found that there was no justification for introducing another agency with any degree of operational responsibility.

In general, there is firm agreement for a minimum need to manage and operate some kind of major arterial on the basis of inter-agency agreement on timing and control strategies during the peak-hours, with full control reverting to the local agency's off-peak. However, the idea of one agency taking over operational responsibility during a part of the day was deemed to be impractical and unworkable. The other option of a central agency having total control would clearly not gain consensus support.

2.1.4 - Summary

To summarize, therefore, the following points are established:

1. There is popular support for the operating of (at least) arterials as a distinct network during peak hours.

2. Signal timing and control strategies should be mutually agreed upon between the relevant agencies for peak-hour operations, but the local agency would retain full control off-peak.

3. A single operating agency would not achieve consensus support and so there is no justification for introducing a new agency with operational responsibilities.

Referring back to the options under consideration, the above findings do not support the central agency in an operational role. However, as discussed in section 2.1.2.1 (above), there is a demand for a central agency in more of a supporting role.

The initial assessment already resulted in a program oriented towards a regional approach; the remaining differences between the R2 and R5 options, therefore, remains the extent of coverage i.e. all intersections or arterial only. This is further discussed in section 3.5 which also presents the results of the cost analysis.

2.2 PROPOSED ORGANIZATION

2.2.1 Regions

The basis for the proposed structure is the division of the County into regions for operational and maintenance purposes. In doing this, the following guidelines were used:

1. Physical (geographical) boundaries such as ranges of hills were used, as synchronization across these boundaries is not necessary.

2. Non-contiguous cities were put in separate regions.

3. The City of Los Angeles was allowed to be present in several different regions, reflecting the City's own sub-division into distinct traffic areas. No other cities were sub-divided.

4. Use of the identification of "common traffic-oriented interest" as exposed during the Focus Group meetings.

5. Regions were kept of such a size that driving distances (e.g. for regional meetings) would not be prohibitively long (i.e. less than 30 minutes off-peak).

The resultant regional definition, suitably modified to take into account comments made during the second round of focus group meetings, is presented in Appendix C.

2.2.2 Organizational Structure

Exhibit 2-3 shows the key elements of the proposed organizational structure. No hierarchy is implied in the way the structure has been drawn - rather there are three distinct functional areas, those of:

- Operations and Maintenance (O&M)
- Coordination
- Policy

O&M represents the day-to-day tasks of managing the traffic signal infrastructure. This is organized on a regional basis and, where applicable, would include the coordinated operation of major arterials.

Cross-jurisdictional coordination would be realized as a result of agencies agreeing on regional policies at regular Regional Forums where each city is represented. Where applicable, representatives of adjacent regions would also attend to agree on cross-regional boundary operations. These Regional Forums would cement inter-city ties and promote daily contacts outside of the forums. The Regional Forums would also help distribute information and provide the opportunity for regional issues to be aired.

As can be seen, the agencies involved include the County, Caltrans, the Cities and maintenance contractors. It is likely that maintenance contractors would attend Regional Forums by invitation only. The items Local-County and Local-Local are maintenance related and discussed later in section 2.4.

Of course, there are issues which have a broader impact than regionally, and items which will be beyond the capability of the Regional Forum to address. The **Coordination** level exists to satisfy this need. It is envisioned that this level would comprise several groups of individuals representing either a Region, a particular expertise, or a function, depending upon the terms of reference of the group.

Groups would be formed to address such issues as:

- maintenance standards
- equipment specifications
- training requirements
- arterial operations

It can be seen in Exhibit 2-3 that peer review is introduced at this level. This represents the concept of problems not having been solved at the Regional Forum, being presented to a wider audience for consideration. The original conception was one of a forum for arbitration; however, this was criticized at the Focus Group meetings and suggested that Cities would be unwilling to accept a binding commitment to abide by a "committee's" decision. The consensus view was that the inability to find common ground at the Regional Forum would be an exceptional circumstance, justifying consideration of each such case on its own merits. It is envisioned that this would take place at the Coordination Level and any recommendations be reported back to the Regional Forum.

Coordination groups could be temporary or permanent events. Attendees would volunteer for involvement or, whenever appropriate, would be elected by the regional forum.

Policy is the third level and comprises two steering committees. One group is the Technical Steering Committee made up of agency staff elected to the committee by the Regional Forum but not representing a region or an agency. It is acknowledged, however, that practicality demands permanent Caltrans and County of Los Angeles representation with those representatives being subject to approval by a majority of the Regional Forums.

The second steering committee is made-up of elected representatives (i.e. council members) who have been elected to the Committee by the Councils in the Cities. It is considered that such a far reaching program as this countywide initiative, demands the involvement and support of elected officials to bring the political perspective to bear.

2.3 SIGNALS SECRETARIAT

2.3.1 - Role

At the onset of the study, it was decided to allow the need for a central agency to develop of its own accord rather than pre-define one and amend it to suit the findings of the study. As described above, a requirement has emerged as being for a supportive, coordinating agency rather than a "hands-on" operational one. To reflect this and avoid preconceived ideas, it has been decided to use the name Signals Secretariat instead of central agency for this body.

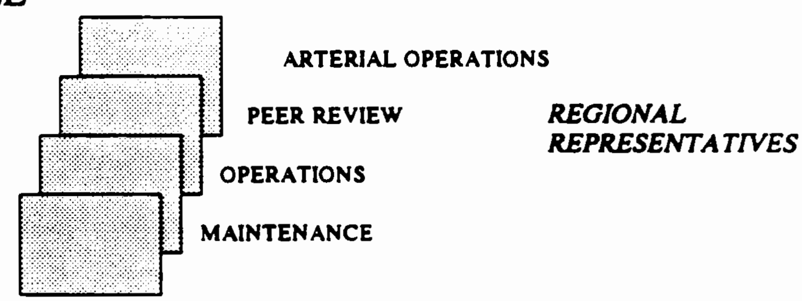
Exhibit 2-3 : Signals Secretariat - Proposed Structure

OPERATIONS & MAINTENANCE LEVEL

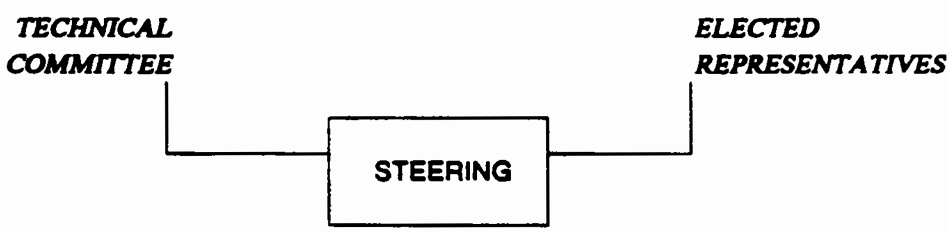
REGIONAL FORUMS

REGION 1	REGION 2	REGION N
City	***City***	***City***
Local - County	***Local - County***	***Local - County***
Contractor	***Contractor***	***Contractor***
Local - Local	***Local - Local***	***Local - Local***
State	***State***	***State***

COORDINATION LEVEL



POLICY LEVEL



The prime role of the Secretariat is to put in place and maintain the organization to support the countywide program. The various functions which this entails are best described under the categories of General, Operations and Maintenance.

2.3.1.1 - General

Among the more general tasks which would be the responsibility of the Secretariat, are the following:

- Policy Definition. The Secretariat would ensure the definition of program policies in conjunction with the Policy-level Steering Committees and establish consensus support for those policies where applicable.

- Funding Appropriation. The Secretariat would identify and secure funds both within and without the County to support the program.

- The setting-up and supporting of the Regional Forums, the Coordination level meetings and the Steering Committee meetings. Secretariat staff would organize and minute the meetings.

- Program Promotion. This would involve the production of any program support material, presentation of the program to agencies, their councils and members of the public.

- Program Audit. This would involve the review and assessment of projects with the agencies involved, to verify compliance with program terms and conditions.

- Define Working Agreements. It would clearly be the Secretariat's responsibility to produce the working agreements upon which the multi-jurisdictional activities would be based.

2.3.1.2 - Operations

Under this category, the tasks of the Secretariat would include the following:

- Establish Technical Resources. This would involve the identification of expert personnel and establishing mechanisms for supplying their services as required.

- Policy Implementation. The Secretariat, through the media of the Regional Forums and the Coordination level meetings, would ensure the implementation of program policies.

- Support Project Definition. This would entail assisting agencies in the definition of local projects and programs.

- Define Operational Procedures. The Secretariat would establish procedures to be followed in traffic signal operations to ensure uniformity throughout the County.

- Establish Training Courses. To tackle the problem of a lack of adequately trained and experienced operations personnel, the Secretariat would establish suitable courses covering such areas as timing plan calculation and implementation, traffic signal equipment availability and use and aspects of signal design.

2.3.1.3 - Maintenance

Secretariat responsibilities under the category of maintenance would include:

- Establish Standards. This would involve the definition and introduction of standards for traffic signal maintenance. This will impact signal maintenance agreements throughout the County in leading to a uniform acceptable level.

- Organize Training. To tackle the problem of lack of trained maintenance personnel, training courses would be established with the aim of building a countywide strength in traffic signal maintenance. Courses would be IMSA certified and eventually support the setting of standards applied for staff recruitment.

2.3.2 - Staffing

It is proposed that the Secretariat have a number of permanently assigned staff in the same way that TRAFFIC has permanent staff members. It will be essential that some members of the staff have previous experience with traffic signal operations and that there is a degree of familiarity with the workings of the agencies within the County.

It would be ideal if it were possible to co-opt staff from other agencies on a part- or full-time basis to provide the Secretariat with expertise when applicable; the staff costs being paid for by the Secretariat. A major problem with such an arrangement may be the handling of such items as pension and other staff benefits between the agencies involved. The only way of assessing the practicality of such an approach may well be on a case-by-case basis with an agency or agencies willing to pursue such an arrangement.

Funding issues are discussed in Section 2.5

2.3.3 - Location

The Secretariat, if created in the form proposed, would exist as an independent agency for legal purposes. This will be essential if it is to be able to secure and distribute funding. However, in practical terms, it will benefit from being accommodated within the facilities of an existing agency to take advantage of an existing infrastructure.

The agency/organization where the Signals Secretariat might be housed could be chosen from agencies such as the Los Angeles County Transportation Commission, the Los Angeles County Department of Public Works, the Los Angeles City Department of Transportation, Caltrans, or any other agency/organization acceptable to the TRAFFIC Committee, and the agency to house the Secretariat.

2.4 ADDITIONAL PROGRAM ELEMENTS

There are additional elements of the program which have emerged in the course of the study and which do not readily relate directly to an organizational or technical issues. This section addresses those elements.

2.4.1 - Equipment Procurement

One possible benefit to be drawn from the organization of the cities into regions and the exchange of information associated with the forums is the potential for cities to combine their efforts in equipment procurement. It may well be the case that by pursuing a bulk-purchase arrangement on an annual basis, order contracts will emerge that attract the attention of a wider range of manufacturers, resulting in cost-effective procurement through more competitive bidding.

This can prove to be beneficial to the purchasing agency by avoiding the situation where a city gets locked-in to a certain supplier and dependent upon that supplier's sole support.

It emerged from the round of Focus Group meetings that suppliers to the County are willing to quote the County negotiated price to cities within the County. This is an indication of the leverage that can be obtained when attractive numbers of equipment are involved.

2.4.2 - County Maintenance (Local-County)

Many cities were complimentary of the maintenance supplied by the County under the current maintenance contracts. However, if there was a criticism, it referred to the response time and the feeling that the County was physically located some distance from the City.

It may prove beneficial for the County to examine the possibility of organizing its signal maintenance on the basis of the regions defined as the basis for the countywide program. When this was mooted at the Focus Group meetings, it was pointed out that the County already has maintenance personnel allocated on a district basis in order to have better local response. Presently, a large quantity of spare parts are carried in specially equipped service trucks assigned to District Traffic Signal Repairmen. A person is employed full time to keep the trucks stocked with parts. Additional spare equipment is stored in special cabinets and in County facilities at 30 different locations throughout the County. It is unlikely, therefore, that a response problem can be wholly attributed to a lack of a local spares stock. It may more likely be related to staffing levels.

It is acknowledged that there is a cost implication for decentralizing the maintenance function. However, with the introduction of maintenance standards under this program, it will be possible to compare the costs of different services for the same level of maintenance. (With the disparity in maintenance contracts, this is currently difficult to do.) This may demonstrate that there is the room to improve maintenance support in this manner and allow the County to stay cost-competitive.

2.4.3 - Local-Local Maintenance

The organization described above introduced the concept of local-local maintenance (see Exhibit 2-3). This is the provision of maintenance services by one City to another. Some cities already operate this type of agreement; others have tried and failed primarily because of liability concerns and, in one case, because of a disparity in labor rates between the cities involved.

It is recommended that this type of maintenance arrangement be actively supported under the program as the maintenance of traffic signals by City personnel was generally agreed to be the preferred solution. It is perceived, rightly or wrongly, that the personnel involved felt more accountable for the maintenance and were therefore more responsive.

If cities combine their maintenance needs, it will provide the opportunity for more city-based maintenance teams while at the same time introducing another maintenance option and stimulating competition.

2.5 POTENTIAL FUNDING

This program will require a major funding commitment that will continue over many years. Local agencies, the County, and Caltrans all concur that additional funding is needed to meet the goal of increased coordination. Two potential sources of funding that have been identified are the proposed gasoline tax increase in the

Governor's transportation package and an initiative for a Countywide 1/2¢ sales tax increase.

A secondary source of funding may occur as part of the new national transportation funding measure scheduled to be in place in 1991. It is expected that the funding will include an emphasis in programs which provide cost effective relief to congestion in major urban areas. This program would be well positioned for such funding if it becomes available.

2.6 FINDINGS AND RECOMMENDATIONS

2.6.1 - Findings

The following is a summary of the findings of that section of the study which has examined the organizational and institutional issues associated with the program. This included an assessment of the current signal operations in the County.

- Area-wide coordination is needed and will benefit all motorists Countywide.
- No single, central based system will meet all the needs of every local jurisdiction and such a system would not receive the local support needed for successful implementation.
- There are subregions within the County that exhibit strong identities created by natural boundaries or historical association that lend themselves for coordinating the operation of traffic signals.
- Local agencies have expressed a need for information, technical support, training and educational programs to facilitate the synchronization, operation and maintenance of their traffic signals.
- Uniform standards of operations and maintenance are needed. This need includes standardizing maintenance agreements and guidelines, establishing procurement guidelines for contract maintenance, standardizing cooperative agreements between adjacent cities and establishing technical and performance standards.
- A major benefit of a regional program would be the reduction of traffic congestion on major arterial streets and highways, the reduction of the associated environmental impacts, and the reduction in use of local residential streets by traffic bypassing congested major streets.
- Additional funding sources for such a countywide program are in the process of being prepared for voting on by the public.

2.6.2 - Recommendations

The following recommendations have been formed on the basis of the above analysis:

- A countywide program should emphasize a regional concept with coordination policies set by the local agencies in each region and should, as a minimum, address the major arterials in the County.

- A Signals Secretariat should be establish to provide regional support. This entity would provide needed technical support, training and other functions as identified by the local agencies. The Secretariat would also secure and distribute funds under the program.

- The Signals Secretariat's location should be determined by TRAFFIC and have permanent staff associated with it.

- The Signals Secretariat should be established in time to prepare programs to take advantage of any funding that becomes available in 1990 and has been identified for use in transportation.

- Two Steering Committees should be established to set and monitor overall policies. One should be made up of technical agency staff, voted on to the Technical Committee. The second should be made up of elected members, voted to serve on the Elected Representatives Committees.

3. TECHNICAL ISSUES

3.1 INTRODUCTION

This section describes the various technical alternatives which have been developed for meeting the overall program goals; to discuss the technical issues, constraints, and cost components associated with each alternative; and to present JHK's initial cost assessment for implementing these alternatives on an agency-by-agency basis. The general guidelines that were used in developing the analysis are also summarized.

Part 3 of Working Paper No. 1 -- "Preliminary Assessment of Alternatives" -- presented the following summary of Technical Alternatives:

1. Coordinating Intersections

   a. Time Based Coordination

      (i) WWV clock synchronization

   b. Systems

      (i) incorporation into existing system(s)
      (ii) install new system countywide (considered infeasible)

2. Coordinating Systems

      (i) incorporation of existing systems into an existing system
      (ii) common time-base
      (iii) consolidation by replacing systems

Specific technical details and the operations and maintenance requirements for each of the above alternatives have been developed based on the existing and planned systems within the County and the current state-of-the-art in traffic control. A description of the final alternatives, including their various cost components, are provided in section 3.3.

Prior to the description of alternatives, section 3.2 presents an overview of various issues and constraints associated with each of the traffic system options (i.e., WWV time-based coordination, closed-loop systems, Multisonics VMS centralized system, UTCS (ATSAC) system, and centralized-distributed systems), and how these system attributes impact the project goals and program implementation.

Section 3.4 presents JHK's initial assessment of the alternatives for each agency within the County. It is essential that the reader view this assessment only as preliminary. Its purpose is to indicate the magnitude of program costs, and to provide a framework for subsequent discussions with the impacted agencies.

Finally, section 3.5 summarizes the findings and recommendations resulting from this stage of the study.

3.2 ISSUES

3.2.1 - Coordination Options

The Appendices of Part 1 of Working Paper 1 ("Presentation of Alternatives") summarizes various forms of traffic control systems in current use. Appendix E of this document reproduces the section on inter-equipment coordination using a common-time reference. The following system and coordination options are under consideration for the Los Angeles County program:

- o WWV Time-Based Coordination
  - individual intersections
  - systems
- o Distributed-Master ("closed-loop") Signal Systems
  - 170-based
  - NEMA-based
- o Centralized Signal Systems
  - Multisonics VMS-220
  - UTCS (ATSAC)
- o Centralized-Distributed Signal Systems

The purpose of this section is to highlight specific system features and constraints that may impact the County's coordination goals or otherwise limit the use and/or expansion of the above systems in the overall program. Any assumptions that have been made in configuring the technical alternatives and their corresponding cost components are also discussed.

3.2.2 - Communication Needs

Beyond the requirement for synchronization, there can be identified a number of functions the support for which dictates the need for two-way communications between on-street and central equipment. Four categories encompassing such functions can be identified as follows:

1. Monitoring

(the ability to remotely monitor the on-street equipment to identify malfunctions and support the maintenance activity)

- this would be expected to offer the benefit of improved coordination reliability to offset the increased maintenance and operations costs

2. Controller Programming (Upload/Download)

(microprocessor-based controllers offer the possibility of allowing the loading and changing of traffic signal timing plans from a remote point without the need to go out on the street)

- this would support operations in terms of modifying plans and TOD schedules to accommodate unforeseen traffic conditions e.g. specials events.

3. Active Management

(the ability to collect traffic data in real-time and distribute the information to motorists using such means as Highway Advisory Radio, Teletext and In-Vehicle Navigational aids)

- this has the potential of affecting the demand rather than supply side of the urban "congestion" equation by affecting driver trip and route choices.

4. Remote Data Collection

(with the advent of Intelligent Vehicle and Highway Systems (IVHS) will come the possibility of extracting data from vehicles to aid in traffic condition assessment (mean speeds, travel times, etc.) and active management (e.g. destination and route choice))

- advantage can only be taken of such capabilities with the availability of an area-wide communications network.

It has been pointed out that there are certain liability issues raised by improvements to the maintenance and monitoring capabilities of an operating and maintenance agency. Firstly, knowledge of a problem carried also the responsibility to respond and repair. Failure to do so in a reasonable time could imply negligence. This puts a specific onus on the need for reasonable but specific response times in maintenance contracts.

Secondly, in some cases where intersection equipment is of an older type, it would be mandatory to carry out a significant controller or intersection upgrade to meet more recent safety requirements (e.g. provision of a conflict monitor). Failure to do so could imply liability in the event of an accident at the intersection.

There is an inherent implication that easier access to signal timing plans makes for more efficient operations as plans can be kept up-to-date. It was pointed out by County engineers that the practice of extensive detectorization coupled with WWV radio clock maintenance and common cycle time zero referencing with long-term forward plan scheduling adds flexibility to the controller. This reduces the need for frequent signal timing plan and schedule revision to those cases where traffic flows are:

a. subject to change due to geographical/zonal use changes

b. subject to unpredictable change due to special events or incidents

Finally, it should be recognized that the move to more complex equipment brings with it cost implications in terms of maintenance. In addition, there may also be an increased operational and maintenance burden due to the introduction of new technologies, and the need for developing new skills.

In assessing the various equipment options, it is essential that the needs and resources of the operating agency are taken into account, and the equipment choice based upon the ability of the equipment to satisfy that need. It is not uncommon to apply a utility analysis method whereby functions are listed, the equipment's ability to provide the function is rated or scaled, and then the importance of that function to the agency ranked or weighted. Factoring the scale against the weight provides a numerical comparison of the equipment.

A list of typical functions to be used in such an assessment is given in Appendix F.

Clearly, it is not possible to carry out a detailed analysis of this per City. Section 3.4.2 explains the process used in this study to establish a program level cost for use in the future.

3.2.3 - WWV Time-Based Coordination

3.2.3.1 - Coordinating Intersections

Installing time-based coordination units with WWV technology at individual intersections appears to be a very cost-effective way to provide coordination between intersections, regardless whether they are located in the same jurisdiction or in different jurisdictions. The radio-based common time information permits the time-based control elements (e.g. selection of timing plans, cycle reference points) to be synchronized. Full details are given in Appendix E of this report.

This approach to coordinating intersections has the following advantages:

1. low initial installation costs on Type 170 controllers (see Appendix A page A-4)
2. no communication line lease fees
3. no interconnect cable requirement
4. little or no additional equipment maintenance costs as those associated with other systems

Clearly, in terms of attaining the goal of synchronization, this particular application of time-based coordination with an accurate time source meets the program's needs at a lower cost than other alternatives.

The lack of dependence upon a physical communication link does mean, however, that there is no communications link between a central point e.g. the signal shop, and the on-street equipment. Thus, timing plan updates and other adjustments (e.g. special events) can be accomplished only be sending staff out to the field. Furthermore, this technology does not provide monitor data regarding signal operations and other hardware conditions. Equipment malfunctions are a fact of life -- they are going to occur regardless of the type of system installed. A serious failure (e.g. signals flashing, controller stuck) will typically be reported by the police or citizenry fairly soon. However, a minor or sporadic malfunction that causes erroneous splits may go unnoticed for some time. Long-term disruption of signal coordination, even at a single signal location, can cause less than optimal operational efficiency and increases in delay -- a situation that is contrary to the overall program goals.

Given the above, it is envisioned that application of WWV technology at individual intersections will be most suitable where operational and maintenance requirements do not demand two-way communications (see Section 3.2.2) or where funding limitations prohibit the use of interconnect. In addition, WWV is the most suitable solution for providing time-based inter-system coordination. Installing an external WWV clock at the central computer of each system will provide the necessary synchronization of cycles for all controllers in the systems. It then remains for the Regional Forum to ensure that identical cycle lengths and compatible offsets are used by the systems within the boundary areas.

3.2.3.2 - Coordinating Systems

JHK & Associates completed a study of a Comprehensive Signal Coordination Plan in 1988 for Orange County. There were already a large percentage of cities in Orange County which were using centralized systems for traffic control, and the County wished to establish a means for coordination across these jurisdictional boundaries.

The overall recommendation was for the use of WWV radio as the common time base, for both individual intersections and existing systems.

3.2.4 - Arterial Master Systems

This system option impacts the program in that many arterial master systems are already operating in the County. The technology of these existing systems varies widely. Some of the systems are fairly simple, consisting of a master time clock which selects timing plans (i.e., combinations of cycle, split, offset) on a time-of-day/day-of-week basis. The timing plans are implemented by energizing with 110 Vac or 24 Vdc specific conductors of random-lay interconnect cable which in turn activate corresponding cycle (or dials in the case of electromechanical controllers), offset settings, and or split settings. The controllers in these basic arterial master systems consist of either electromechanical pretimed, NEMA, or Type 170 controllers; mixed controller types in the same system are not uncommon in the County.

Some of the existing arterial master systems are quite advanced. They consist of an intelligent field master which provides two-way communications with the local controllers over twisted-pair cable. In essence, these systems are closed-loop systems, except that the link to a central computer has not been provided.

The arterial master systems have the same operational limitations as time-based coordination. Because there are no communications between the control hardware and the operations/maintenance offices, timing plan adjustments must be manually accomplished in the field, and hardware failures and coordination problems may not be immediately reported. It is noted, however, that since interconnect cable and conduit already exist between the intersections in this type of system, communications costs should be significantly reduced to enable connection to some form of central monitoring equipment. (This is assuming that the old interconnect cable (typically random-lay) can be removed, and new twisted pair communications cable installed in the same conduit.)

With more advanced arterial masters, modification to allow dial-up communications as part of a closed-loop system can be particularly effective (see 3.2.5 below).

3.2.5 - Closed-Loop Systems

Several closed-loop systems are already operating in the County (e.g. Inglewood, Pomona, South Gate), and others (eg. Gardena) are planned for the future. Closed loop systems remove some of the limitations of arterial master systems described above, by adding a remote (central) monitoring capability. This typically takes the form of a PC with a dial-up capability. An arterial master may be upgraded to have a dial-up interface hardware with suitable software to respond to commands issued by the central. Central to master communication is established, therefore, via the switched telephone network.

Typical features of such systems include real-time monitoring of phase green along an arterial and upload/download of signal timing plans and plan selection schedules.

Closed Loop systems ar attractive in their ease of upgrade from already installed arterial masters, ability to work with dial-up telco lines and relatively inexpensive equipment costs (see Appendix A-14). There are, however, potential limitations in using this type of system (either new or expansion of existing) to accomplish the program goals. These issues are summarized below:

- o Coordination between signal groups may be limited. This is due to the fact that the coordination is maintained by the accuracy of the clocks in the individual controllers. These local clocks are reset by the field master which, in turn, is reset by the central microcomputer. If clock resetting is infrequent, coupled with the typical inaccuracy of the clock in the PC, it is very possible that local controllers in different field-mastered groups may not be using a common time reference. Fortunately, this limitation can be overcome. A WWV time standard board is available which can plug into an IBM PC or compatible microcomputer. This not only improves the accuracy of the PC clock, but also permits multiple closed-loop systems to use the same time reference. Additionally, in most systems, it is possible to schedule the frequency at which the field master clocks (and therefore the local clocks) are reset.

- o Closed-loop systems do have a practical size limitation. In theory, a typical system with a "capacity" of 16 field masters and 32 controllers per master can control a total of 512 intersections. In reality, however, the number is much smaller. On the one hand, signal groups -- particularly along arterials -- seldom come close to having 32 signals in them. Furthermore, since only one master can communicate with the central microcomputer at a given time, as the number of field masters increases, so does the response time for reporting problems. In fact, there have been instances where a recurring intermittent problem in one signal group tied up the computer so much that other masters could seldom gain access. This can be minimized by use of a direct, dedicated line between the central PC and the on-street master which would carry an associated cost penalty (see Section 3.3.6).

As with any system, however, the success of the implementation will depend upon the correct choice of link for the given situation. In addition, good system design should mitigate this type of problem.

- The number of on-street masters and local controllers which can practically be accommodated by a closed-loop system is dependent on the agency's level of use of the system. That is, if the agency actively monitors intersection status and schedules the system to report all system events as they occur, the number would be relative low compared to an agency which only wants to periodically check problem locations. Experience to date has indicated that 8 to 10 on-street masters with 75 to 100 intersections reflects typical operation.

- It has been assumed that, when a system in Agency A is to control signals in Agency B, Agency B will be provided with a remote terminal to monitor and possibly control its signals. Closed-loop systems do provide remote terminal capability -- any microcomputer equipped with the appropriate software and a modem can call up a field master, assuming that the phone number is known. Each field master can also be given unique access codes for control and/or monitoring functions. Furthermore, each field master can be assigned a different phone number (corresponding to a different microcomputer) to call in the event of a malfunction. Thus, depending on the maintenance arrangements, the field master(s) in Agency B could call Agency B's microcomputer; or if Agency A was the maintaining agency, these field masters could be programmed to call Agency A's PC. A potential problem with remote terminals in a closed-loop system is maintenance of an accurate central data base. If timing changes are made from a secondary microcomputer (e.g. Agency B), these modifications are <u>not</u> automatically entered into the central data base of the primary microcomputer (e.g. Agency A). Coordination between agencies will therefore be crucial in this regard.

- Two types of closed-loop systems are available -- NEMA-based and 170-based. The NEMA-based systems are offered by controller manufacturers. Each of these manufacturers have developed unique hardware and software that is proprietary to their particular system. As a result, the same hardware (both controllers and field masters) must be utilized throughout the system. This means that if a NEMA-based closed loop system is to be expanded to include another agency's signals, the controllers in the expansion area will almost undoubtedly require replacement , regardless of their age or capabilities, so as to match the controller hardware in the existing system. It is noted that Type 170-based closed loop systems are much better in this regard. Any Type 170 controller can be integrated into the system provided it has the communications module and the appropriate local firmware. It has been assumed, however, that if a 170-based closed loop system is expanded beyond an agency's boundaries, an additional firmware license will be necessary.

3.2.6 - Centralized Systems

Two types of centralized systems are operating in the County as follows:

- UTCS-Enhanced (Los Angeles ATSAC)
- Multisonics VMS Systems

The LADOT Automated Traffic Surveillance and Control system (ATSAC) uses the UTCS-Enhanced software as its baseline operating package; and with the numerous modifications that have been implemented in the past few years, the ATSAC system now represents one of the most advanced applications of this UTCS package. Expansion of ATSAC to include signals in the County has already been recommended as part of the Smart Corridor concept -- specifically, signalized intersections in Beverly Hills and 26 signalized intersections in Culver City.

The greatest constraint to further expansion of ATSAC appears to be cost. ATSAC uses only Type 170 controllers. Thus, some jurisdictions might be faced with significant replacement of equipment to accommodate the ATSAC system. Depending on the level of expansion, additional central hardware and software, including security provisions for remote terminals, may also be required. The ATSAC program costs are discussed in section 3.

The Multisonics VMS is a proprietary system. It has been installed in Culver City, El Monte, and West Covina. Important aspects of this system, in the context of the overall program, are summarized below:

- Two types of VMS system are relevant to the TRAFFIC program. The VMS 220 is installed in the above mentioned cities. The VMS 330 is the replacement for the 220 and features:

  - redesigned hardware to use more recent integrated circuit technology
  - improved peripherals (floppy and hard disks)

- Multisonics planned to have available by end 1989 as an upgrade to both the VMS 220 and 330 systems, the ability to read an external clock (e.g. WWV time reference)

- The Orange County Transportation Commission (OCTC) is currently organizing a Demonstration Project for the application of WWV techniques to coordinating systems. Out of this work, Multisonics aim to establish software changes which are required to carry-out the zeroing of the cycle timer references.

- BiTran have developed a software package which will allow Type 170 controllers to operate under a VMS 220 master.

- With the use of a Remote Communications Unit (RCU) non-Multisonics controllers such as NEMA types can operate under the VMS master.

- Multisonics offer the MP4 option on VMS 220 masters which allows neighboring masters to synchronize with each other to enable coordinate across the system boundaries. When cycle times are within a pre-defined range (e.g. within 5 seconds) then the master with lower cycle time is forced to use the higher value, thus allowing synchronization.

  Multisonics offer this feature for $2,000. per machine.

3.2.7 - Centralized-Distributed Systems

The centralized-distributed system, being the most recent concept in the system genre, has few limitations for the Countywide coordination program. Perhaps its most attractive feature in this regard is the ability to control Type 170 controllers (with communications module and appropriate firmware) <u>and</u> NEMA and pretimed controllers (via an external remote communications unit

(RCU)) in the same system. Thus, wholesale controller replacements, which have a high probability of occurrence in the previously discussed systems, are not necessary with a centralized-distributed system except for reasons of controller age.

It should be noted that while the RCU allows downloading of signal timing plans and schedules from the central, it prohibits access to the controller's internal parameters. This takes away some of the functionality of the distributed control concept.

It has been assumed that, in expanding a centralized-distributed system beyond an agency's boundaries, additional license fees will be required for the central software and the 170 RCU firmware. This also pertains to expansion of the ATSAC system.

Centralized Distributed systems are characterized by the non-proprietary nature of the central equipment as, typically, general purpose microcomputers are used. Suppliers of such systems are:

FSI Inc. (the MIST system)
JHK & Associates (Series 2000)

It should be noted that the software supplied by the consultants listed above is not in the public domain but licensed by the suppliers for use by an agency. In this respect, the software is proprietary.

3.2.8 - Controller Replacement

In configuring the various alternatives, it has been assumed that all electromechanical controllers will be replaced. It has been further assumed that, in light of the controllers age, those intersections will also require signal modernization and upgrading. Other controller types (e.g. NEMA, Type 170, Solid-State Pretimed) will be replaced only if required for system compatibility. It is acknowledged, however, that there are pre-NEMA, solid state controllers that should be replaced.

3.3 ALTERNATIVE SYSTEMS

This section describes the final alternatives for the Los Angeles County program and the various capital cost components associated with each alternative. The alternatives are summarized below:

1. COORDINATING INTERSECTIONS

   a. WWV Time-Based Coordination

   b. Incorporate Intersections Into An Existing System

      (i) Existing system is a Type 170 Closed Loop
      (ii) Existing system is a NEMA Closed Loop
      (iii) Existing system is a Multisonics VMS

(iv) Existing system is a UTCS (ATSAC)
(v) Existing system is a Centralized-Distributed

2. COORDINATING SYSTEMS

a. Common Time-Base Between Systems

b. Incorporate Existing System (A) Into Existing System (B)

(i) System (B) is Type 170 Closed Loop
(ii) System (B) is Multisonics VMS
(iii) System (B) is UTCS (ATSAC)
(iv) System (B) is Centralized-Distributed

c. Consolidate Existing Systems A & B into a new System (Closed Loop or Centralized)

The cost components for each alternative have been categorized as follows:

- **Per Intersection Costs** - these costs apply to each intersection. Representative components include controllers (complete with cabinet and accessories), signal upgrades, system detector loops, interface hardware (e.g. communications modules, RCU, TBC units, etc.), field masters (pro-rated at an assumed average of 10 controllers per master), communication costs (i.e., twisted-pair cable in conduit over a distance of one-quarter mile) and integration (e.g. design, construction management, data base development, and intersection pick-up).

  It should be noted that in order to provide a fair comparison of costs, the same degree of detectorization is assumed for all upgraded intersections.

- **Per System Costs** - these costs are essentially independent of the number of intersections. Representative components include central hardware and software, remote terminals, licensing fees, and communications trunk lines.

Where Type 170 firmware license costs are shown under system costs, this means that the cost is independent of the number of intersections involved.

Cost build-up matrices for each alternative are provided in Appendix A to this report.

3.3.1 - Coordinating Intersections With WWV Time-Based Coordination

In this alternative (1A), external WWV time-based coordination units are installed at intersections which presently have no coordination capability at all, or have TBC coordination but without WWV. A representative unit is the SETCON Model TR 600 (refer to catalog cut in Appendix C of Working Paper 2 Part 1). Also included in this alternative is the installation of a WWV module at Type 170 controllers which are operating only with the internal time-based coordination capability (i.e., non-interconnected). Prices are based upon the County's current choice of Traconex WWV unit.

3.3.2 - Coordinate Intersections By Incorporation Into Existing Systems

Under this system alternative (1B), non-interconnected intersections are integrated into an existing signal system. This includes intersections with and without time-base coordination capability. Some of the cost components in this alternative merit special consideration as noted below:

- Controller costs for the existing NEMA-based Closed Loop system and the Multisonics VMS are higher than the NEMA controller costs which are used elsewhere in the analysis, reflecting that these units must be purchased on a sole-source basis (i.e., competitive bid cannot be used for these proprietary items).

- ATSAC expansion costs are based on the City's own costs used for budgeting purposes.

3.3.3 - Coordinating Systems By Providing A Common Time-Base

This system alternative (2A) involves installation of an external WWV clock at the central computer. Representative units include the VAX Time Source (for the VMS and Centralized-Distributed Systems) and the CTL-WWV plug-in board for closed-loop systems. With respect to the latter unit, the County has had one on order since 10/06/89. At the time of writing, there has been no delivery and, as such, the unit remains untested and unproven. It is noted that the ATSAC system already includes an external WWV clock.

For an arterial master system, the common time reference will be maintained by installing some form of WWV device at the master location. Arterial master systems that consist of solid state controllers interconnected with random-lay cable will normally require the installation of a SETCON Model TR 600 as the system master, including connections to the interconnect cable. Type 170-based arterial master systems will require the installation of the WWV module at the master.

3.3.4 - Incorporate Existing System (A) Into Existing System (B)

Traffic coordination between two agencies is maintained under this alternative (2B) by integrating the signals in Agency A (which has its own system) into the signal system of Agency B. There are numerous possibilities when one interconnected system (operating in Agency A) is incorporated into another system (operating in Agency B). However, as can be seen in Exhibit 3-1, only a few combinations -- all involving a more "advanced" System A as compared to System B -- are really feasible. Furthermore, in developing the cost components for this alternative, it has been assumed that the existing System B has sufficient capacity (i.e., central hardware and software, communications trunks, etc.) to control all the signals in System A.

Many of the permutations of this alternative have unique or special communication requirements, as summarized below:

- Arterial master systems already have existing interconnect. It has been assumed that the existing cable can be removed and new twisted-pair cable installed in the same conduit, thereby significantly reducing communication costs.

  It should be noted, however, that this may not always be the case and that any new cable will have to be buried and new conduit laid. This would have a significant cost impact. It is not possible to accurately assess the real cost of upgrade without a detailed field survey which is impractical at this level of study. Similarly, it would be unrealistic to calculate new, buried cable everywhere. For these reasons, an additional contingency sum of 5% has been added to the normally acceptable 10% to cover this specific item.

  Additionally, in some cases, random lay cable may be suitable for use in the upgraded system. This, however, can only be established as a result of a detaled site survey and cable test.

- A communication schematic for the scenario where a closed-loop system or arterial master system is incorporated into a centralized system is shown in Exhibit 3-2. In essence, the intersections in each field mastered group are configured into communication channels for the central system (6 intersections per channel assumed). These remote channels are then interfaced with the central computer via dedicated full-duplex data circuits leased from the telephone company. (It is recognized that there is a history of poor experience with the use of leased telephone lines

EXHIBIT 3-1 ALTERNATIVES MATRIX - - INCORPORATING SYSTEM "A" INTO SYSTEM "B"

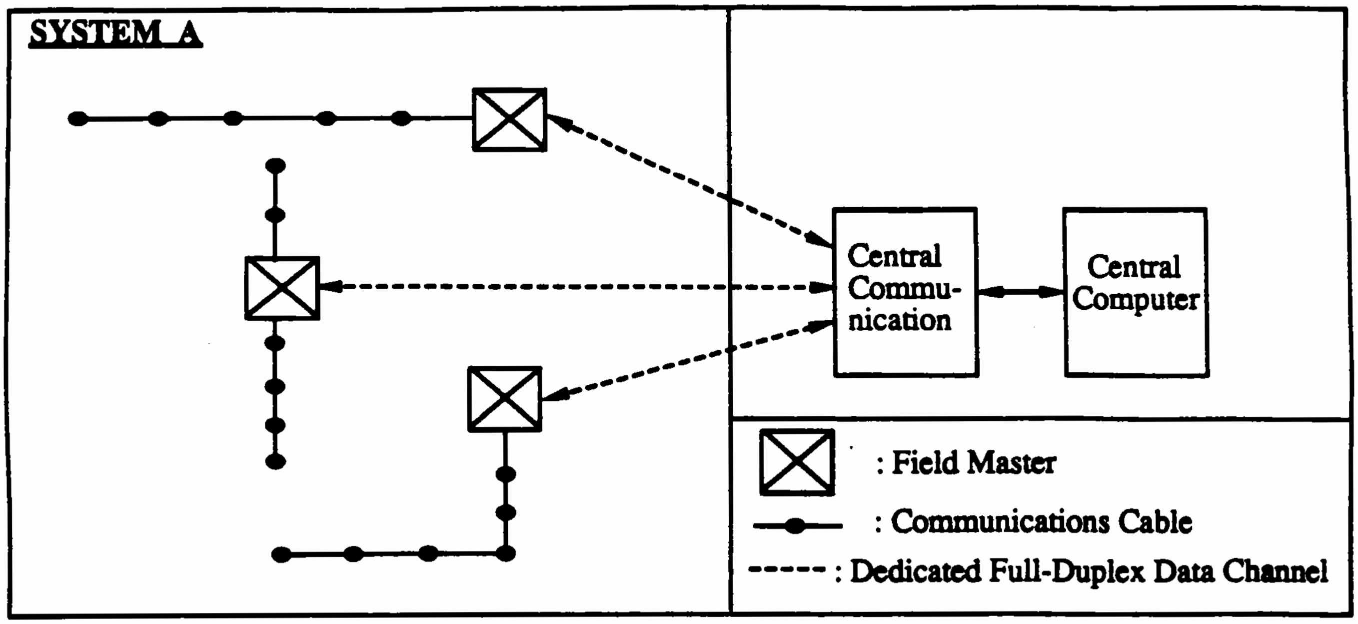
A \ B	Arterial Master (other)	Arterial Master (170)	Closed Loop	VMS	ATSAC	Centralized-Distributed
Arterial Master (other)	⊗	⊗	●	●	●	●
Arterial Master (170)	○	⊗	●	●	●	●
Closed Loop	○	○	⊗	⊗	●	●
VMS	○	○	○	⊗	●	●
UTCS Enhanced	○	○	○	○	⊗	⊗
Centralized-Distributed	○	○	○	○	⊗	⊗

● = **Viable Alternative**

⊗ = **Not Viable - Little or No Increase in System Features and Capabilities; Coordination Can Be Acheived Through Common Time Reference at Central**

○ = **Not Viable - Reduction in System Features and Capabilities**

EXHIBIT 3.2 - COMMUNICATION SCHEMATIC - INCORPORATION OF CLOSED LOOP / ARTERIAL MASTER SYSTEM INTO CENTRAL BASED SYSTEM



Notes:

1. Field Master function removed as it becomes redundant.
2. Re-cabling of intersection interconnect is needed.

for traffic control purposes. But it is likely that such lines, as proposed here, are more likely to appear as "normal" data circuits than central to intersection lines and so not be subject to adverse handling by the telephone company. However, should an alternative to this approach be identified during a design phase of this program, it should be considered.)

It is assumed that new twisted-pair cable will be installed (in existing conduit) between the intersections within each previously field-mastered group. Depending on the number of intersections on a group and the size of the existing cable, this cable replacement effort may not always be necessary. However, in order to develop order-of-magnitude costs for the program, a conservative approach has been taken.

- Exhibit 3-3 shows the communications schematic for the scenario where a centralized system is incorporated into another centralized system. The communications cable network for System A is interfaced with System B's central computer via a leased T1 data channel (providing an average of 52 communication channels) and appropriate multiplexing equipment.

3.3.5 - Consolidate Existing Systems A and B Into A New Centralized System

This alternative (2C) is very similar to alternative 2B; except that instead of integrating one system into the other, a new system -- either closed-loop or centralized -- is installed to control the signals in Agency A and Agency B. The communications network configurations previously described in section 3.4 for alternative 2B are also applicable to this alternative. Additionally, with the installation of a new, more advanced system, it has been assumed that the staffs of the two agencies will require training. Extensive documentation will also be required.

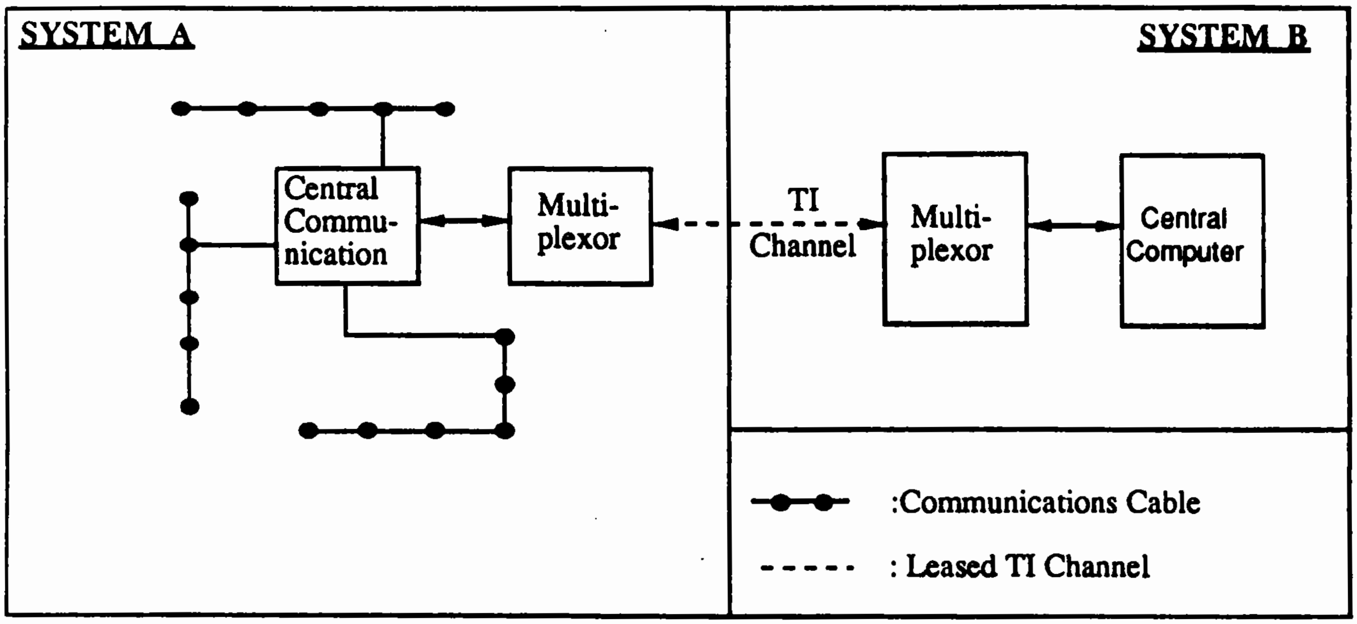
It should also be noted that the one-time system costs associated with a wholly new closed-loop or centralized system are represented in this section.

3.3.6 - Communications

Section 3.3.4 (above) explains how the communications requirements for various system combinations have been taken into account. In establishing the costs, it has been assumed that city-owned cable will be used for interconnect. This has ben chosen because of the widespread preference in the County for city because of the widespread preference in the County for city ownership of cable rather than line rental from the telephone company.

There are a number of options available for data communication with the various system alternatives. These can be summarized as follows:

EXHIBIT 3-3 COMMUNICATION SCHEMATIC - INCORPORATION OF CENTRALIZED SYSTEM INTO A CENTRAL BASED SYSTEM



a. central to intersection (e.g. in centralized systems)
   - leased (dedicated) telephone lines
   - agency owned

b. central to master (e.g. in closed loop systems)
   - as above
   - dial-up
   - radio

<u>Note</u>: There has been, in the Los Angeles area, a history of poor experience with leased telco lines due to poor service.

Radio is currently being assessed for use in Long Beach (900MHz range) and Lancaster (400MHz). The drawbacks of the widespread application of radio are documented elsewhere (see Working Paper 1 Part 4 and its Addendum), but clearly frequency availability is an issue. When used in traffic control systems, radio offers an alternative to dial-up communications e.g. in a closed-loop system, as is the case in Long Beach.

For the sake of completeness, Exhibit 3-4 presents a comparison of costs for leased Telco and city-owned hardwire transmission systems, and for radio dial-up communications.

Maintenance costs are based on 10% of capital cost per annum for equipment and 2% for buried interconnect. (These figures are derived from the consultant's experience of such costs).

As can be seen, considering only initial installation cost, leased Telco lines are the lowest cost option, but city-owned cable is more cost-effective over a longer period.

The cost trade-off between dial-up and radio will depend upon the operational requirements of the City. Radio provides, for the higher cost, more direct, quicker and more secure access to the street from a central than dial-up. However, frequency availability is likely to continue to be the overriding factor in the use of radio.

c. central to central (i.e. trunk communications)
   - leased trunk line (e.g. T1)
   - agency owned facility
     - fiber optic
     - microwave
   - CATV

Exhibit 3-4 : Cost Comparison of Communication Media

1: Leased versus Agency-owned interconnect					
Configuration	Closed Loop/dial-up PC central/leased interconnect				
Option	Equipment Type	Number of Units	Installation Cost	Annual Cost	10 year cost
Leased Telco	Intersection	64	$2,500	$6,204	$4,130,560
	Master		$2,500	$6,204	$0
City Owned	Intersection		$20,000	$400	$0
	Master		$20,000	$400	$0
Dial-Up	Master	2	$2,000	$360	$11,200
Radio	Intersections		$3,000	$300	$0
	Central		$5,000	$500	$0
				Total System Cost	$4,141,760
Configuration	Closed Loop/dial-up PC central/agency-owned interconnect				
Option	Equipment Type	Number of Units	Installation Cost	Annual Cost	10 year cost
Leased Telco	Intersection		$2,500	$6,204	$0
	Master		$2,500	$6,204	$0
City Owned	Intersection	64	$20,000	$400	$1,536,000
	Master		$20,000	$400	$0
Dial-Up	Master	2	$2,000	$360	$11,200
Radio	Intersections		$3,000	$300	$0
	Central		$5,000	$500	$0
				Total System Cost	$1,547,200

2: Radio versus dial-up					
Configuration	Closed Loop/PC central/radio communication				
Option	Equipment Type	Number of Units	Installation Cost	Annual Cost	10 year cost
Leased Telco	Intersection		$2,500	$6,204	$0
	Master		$2,500	$6,204	$0
City Owned	Intersection		$20,000	$400	$0
	Master		$20,000	$400	$0
Dial-Up	Master		$2,000	$360	$0
Radio	Intersections	64	$3,000	$300	$384,000
	Central	1	$5,000	$500	$10,000
				Total System Cost	$394,000
Configuration	Closed Loop/PC central/dial-up to intersections				
Option	Equipment Type	Number of Units	Installation Cost	Annual Cost	10 year cost
Leased Telco	Intersection		$2,500	$6,204	$0
	Master		$2,500	$6,204	$0
City Owned	Intersection		$20,000	$400	$0
	Master		$20,000	$400	$0
Dial-Up	Intersection	64	$2,000	$360	$358,400
Radio	Intersections		$3,000	$300	$0
	Central		$5,000	$500	$0
				Total System Cost	$358,400

The County of Los Angeles currently has installed widespread telecommunications base employing the following media:

- microwave
- leased Telco lines
- fiber optic links

The investment needed to implement the expanded fiber optic network, which is currently a conceptual design, is likely to preclude its immediate application as part of a wide-area signal control system. However, as evidenced by the expansion of the ATSAC system and the recommendations for the use of fiber trunks as part of the Smart Corridor Control system, fiber optic communication should be considered as a future system component.

Given the County's experience of operating leased Telco trunk facilities, it is unlikely that there will be internal support from the County for continued or expanded use of this facility. But, as noted in Section 3.3.4 (above), this may not be justified in the case of trunk facilities.

The extent of the County's microwave communications network is such that it is likely that existing equipment can be used to satisfy a countywide traffic control system's trunk communications requirements.

3.4 ASSESSMENT OF ALTERNATIVES

3.4.1 - Area of Coverage

Section 2.1.1 of this report reviews the assessment of the alternatives and details the elimination of alternatives to derive alternatives R2 and R5. These alternatives differ in their area of coverage in that R2 considers all intersections as part of the program while R5 considers arterials only.

3.4.2 - Cost Evaluation Process

3.4.2.1 - Capital Costs

The evaluation of capital and implementation costs was conducted on an agency-by-agency basis, and involved a comparison of the coordination needs and agency capabilities with the attributes of each system alternative.

The process did not include a formal cost-benefit or utility-cost process, but instead relied heavily on the experience and engineering judgement of the project staff with input from the expert panel of JHK employees. The "criteria" that were used in the evaluation are summarized below.

Using the cost matrices described in section 3, together with the application of the criteria described below, costs have been developed for each City in the County for the two alternatives for program coverage, namely all intersections or arterials only. The objective has been to develop program level equipment and implementation costs over and above those already funded by programs. A more detailed analysis would need to be carried out in conjunction with each agency to establish the most suitable approach and provide a more accurate estimate of costs.

For those unincorporated areas which are operated and maintained by the County, a separate assessment per region has been made. Of particular note is the widespread use of arterial masters, which has led to the provision of "upgrading" to closed loop systems in the analysis. As the County signal shop would be the central monitoring point, it would be unrealistic to assume a central PC for each arterial master. A PC per region (given a total of 4) has therefore been allowed for (as County terminals) in the costing summary for those regions with Unincorporated areas in which arterial masters have been identified as part of a closed loop system.

The costs are summarized per city in Working Paper 2, Part 2 and per region in Exhibit 3-5. A contingency sum of 10% of total cost has been included. This is common practice in system cost estimating. An additional contingency of 5% has been added to cover uncertainties in the ability to re-use existing interconnect conduit (see 3.3.4).

3.4.2.1.1 - Operations and Maintenance

The technical alternatives were configured to provide inter-agency as well as intra-agency coordination of signals. However, after the coordination program is in place, the key to its continued success will be an effective program of operations and maintenance. This requires an adequate staff of well-trained personnel, up-to-date documentation on all system components, adequate budget for spare parts and expendables, and a long-term commitment on the part of the County agencies to utilize those systems -- both technical and institutional -- to their full potential, including keeping the timing plans up-to-date and compatible.

System alternatives that enhance these operational and maintenance endeavors (e.g. permit signal timing plan parameters to be changed from a central location; provide real-time diagnostics of system components; immediately report equipment malfunctions and their nature, etc.) were "rated" very high during the evaluation process. At the same time, alternatives which place too heavy of a burden on agency staff (in terms of system complexity and/or staffing requirements) were not favored.

3.4.2.1.2 - Compatibility

The overall program must be compatible with each agency's coordination needs. Thus, each alternative was evaluated in terms of the following two options:

- o Provide inter-agency coordination only on major arterials
- o Provide inter-agency signal coordination on all boundary crossings

Other compatibility considerations included existing/future systems in each agency; existing and projected system sizes; and the types of controllers in each agency, including any controller standards (e.g. Type 170) that have been adopted.

3.4.2.1.3 - On-Going City Programs

As stated in section 4.2, the capital costs developed are meant to establish the level of costs associated with the two program alternatives analyzed over-and-above those costs already funded. Thus, for example, the costs for the implementation of the Pasadena system are not considered, as this program is already fully funded from a combination of City and County funds.

In contrast, the City of Los Angeles' program for the further integration of some 3000 intersections is not, as yet, fully funded. Exhibit 3-5, therefore, includes a provision for the City of Los Angeles' program. This has been calculated on the basis of 3000 intersections for alternative R2 and 2250 (75% of all intersections) for alternative R5, at a per intersection cost of $60,000 (the City's own budgeting figure).

3.4.2.1.4 - On-Going Programs

The County of Los Angeles has established a significant program for the implementation of WWV technology within the County. The 5 year plan proposes WWV control of 1026 intersections at a cost to the County of $6,297,725 and to the Cities and State of $5,060,125. (An average cost of approximately $11,000 per intersection which includes upgrading to full traffic actuated operation.)

As stated in section 3.4.2, the objective of the cost analysis has been to establish program level costs, and not make detailed recommendations per city. Each city deserves a more detailed analysis of its specific requirements. It is recommended that the County's on-going WWV program be carefully considered during the assessment of both City and Regional requirements.

Exhibit 3-5 : Summary of Capital Costs for Alternatives

Region	*Alternative R2*		*Alternative R5*	
	Sub-total	*Total*	*Sub-total*	*Total*
Central Western				
1	$11,684,800		$8,003,000	
U	$2,104,400		$1,135,400	
LA	$103,017,000	$116,806,200	$77,262,750	$86,401,150
South Bay				
1	$10,744,700		$6,769,700	
2	$4,894,200		$3,765,000	
3	$1,116,900		$383,100	
U	$2,417,300		$1,221,100	
LA	$6,386,170	$25,559,270	$4,789,628	$16,928,528
West San Gabriel				
1	$7,569,500		$6,293,700	
2	$5,599,400		$5,452,100	
U	$4,565,000	$17,733,900	$3,810,600	$15,556,400
East San Gabriel				
1	$6,120,800		$4,800,000	
2	$2,707,000		$1,899,000	
U	$4,376,100	$13,203,900	$2,525,200	$9,224,200
South-East				
1	$12,286,300		$10,196,800	
2	$11,591,500		$9,254,000	
3	$1,659,000		$1,078,500	
U	$3,759,500	$29,296,300	$1,976,500	$22,505,800
Harbor				
1	$17,871,100		$14,095,000	
2	$8,996,500		$7,659,200	
U	$910,100		$475,100	
LA	$5,830,000	$33,607,700	$4,372,500	$26,601,800
Agoura/Westlake				
1	$925,700		$925,700	
U	$66,000	$991,700	$66,000	$991,700
San Fernando Valley				
1	$9,054,600		$7,119,000	
LA	$57,950,750		$43,463,063	
U	$214,700	$67,220,050	$117,800	$50,699,863
Pomona		$6,405,100		$4,903,100
Antelope Valley		$1,568,300		$868,400
Santa Clarita		$1,385,100		$1,385,100
Sub-total (1)		$313,777,520		$236,066,040
OTHER :				
County Terminals		$100,000		$100,000
Sub-total (2)		$313,877,520		$236,166,040
Contingency (15%)		$47,081,628		$35,424,906
TOTAL CAPITAL		$360,959,148		$271,590,946

1. For data handling purposes only, the regions have been divided into sub-regions
2. U - Intersections in unincorporated areas
3. LA - Intersections within the City of Los Angeles

3.4.3 - Operating Costs

As well as estimating capital and implementation costs, it is important to compare the two alternatives on the basis of the recurring annual costs. In doing so, it is necessary to assess the impact of the prospective programs in terms of the increased cost over existing operations and maintenance programs.

The following criteria has been used to establish additional operational and maintenance costs associated with the implementation of the R2 and R5 alternatives:

a. Equipment maintenance: 10% of capital equipment cost per annum
b. Interconnect cable: 2% of installation cost per annum

In addition, in the case of centralized system, the following staffing costs have been added to reflect the increased operational requirements:

a. for each city with a centralized system: one additional person-year per annum

b. for each city supporting operations of another city's equipment or its own system: one additional person-year per annum

Note:

1. These costs are additive in nature, i.e. a City which "gains" a centralized system under a program and supports an adjacent city's intersections under its system is attributed additional staffing costs of two person-years per annum.

2. A person-year's cost has been calculated as an experienced engineer's salary with 100% overhead i.e. $50,000 + 100% = $100,000.

The annual operational costs for each alternative are presented in Appendix B.

In calculating these operational costs for centralized systems it is assumed that the central computer equipment is of the type which does not require a specialized, controlled environment other than a normal working office. Thus, no large central control room is needed.

Furthermore, it should be noted that, in comparison with these costs, the application of WWV at the intersection level contributes little or no cost to equipment maintenance costs (on the basis of the County's experience to date).

3.5 FINDINGS AND RECOMMENDATIONS

3.5.1 - Findings

The following findings have resulted from that part of the study which has examined the technical issues associated with traffic signal operations in the County:

- A single central traffic control system is not a viable option given the levels of diverse equipment invested in the County, the pursuance and justification of different but appropriate technical paths at the local level and the lack of consensus support for such an option.
- The diversity of equipment is such that there exists no single, optimum equipment/technical approach or option applicable countywide.
- Pursuance of Alternative R2 where appropriate would require capital expenditure of approximately $365 million and result in increases in operational and maintenance costs of approximately $3 million per annum. (All estimates are in current dollars.)
- Pursuance of Alternative R5 (covering intersections on arterials in the County) would require capital expenditure of approximately $275 million and result in increases in operational and maintenance costs of approximately $2.5 million per annum. (All estimates are in current dollars.)
- Each city would need to be assessed individually and as part of its region to establish which of the technical options would be most applicable. This study would need to take into account the operational and maintenance requirements of the agencies involved.
- The application of WWV technology is appropriate for providing coordination between individual intersections and between systems.
- Where coordination equipment has to support operations and maintenance activities, then two-way coordination is needed.
- Agencies need not surrender any degree of control or give another agency any degree of control by connecting its signal equipment to that agency's system.

Section 2.6 presents the findings associated with the analysis of the organizational and institutional issues. These include the support identified for arterial coordination.

Alternative R5 would support a program for improved arterial coordination, while R2 represents the costs of extending the coverage to all facilities. The maximum cost: benefit in terms of reduction in delay, fuel consumption and pollution would be associated with R2 as these measures are, to an extent, proportional to the numbers of vehicles in the network.

3.5.1 - Recommendations

Section 2.6 presents the findings associated with the analysis of the organizational and institutional issues. Taking into account this and the above findings, the following recommendations are made:

- The countywide program should be based upon the regional application of systems employing two-way communications with street equipment for the support of operations and maintenance. When such support is not required, then the preferred means of coordinating intersections should be using WWV technology.

- Where groups of intersections are involved, the countywide program should include the application of WWV technology to coordinate systems.

- A prime task of the Signals Secretariat should be the initiation of a program to assess the regional equipment requirements on the basis of the information presented in this study.

4. INCENTIVES

4.1 INTRODUCTION

This section of the final report examines potential incentives which could be effective in encouraging public agencies in the County of Los Angeles to take part in and actively support a traffic signal synchronization, operation and maintenance program.

Incentives have been identified, discussed and developed during the course of the study carried out on behalf of the TRAFFIC committee. In particular, the two rounds of Focus Group meetings have provided an ideal forum for direct discussions with the involved agencies. The potential incentives have been classified into three broad groups as follows:

1. Funding
2. Support Services
3. Other Benefits

Sections 4.2, 4.3 and 4.4 present details of the identified incentives. Section 5 examines the role of incentives within two of the major non-city oriented agencies in the study area, namely Caltrans, and the County of Los Angeles. Finally, section 5 presents the findings and recommendations related to the issue of incentives.

4.2 FUNDING

4.2.1 - Current Practices

The single most obvious form of incentive to take part in a program is that of the provision of funding to an agency. This is already commonly practiced by the Federal Government and is the backbone, for example, of the State's Fuel Efficient Traffic Signals Improvement (FETSIM) program. Other examples currently associated with traffic signal projects include the FAU (Federal Aid (Urban)) and HES (Hazard Elimination Safety) grants.

Funds can be provided for all (100%) or part of the project cost required and are normally calculated based on capital rather than recurring costs. The County itself has a funding program already in place with the specific objective of supporting the installation of WWV equipment. This is a 50/50 program in terms of cost sharing. In comparison, the State offers a 75% sharing of costs associated with their FETSIM program.

The programs mentioned vary greatly in the terms of the funding and the conditions which must be satisfied to make an application eligible for funding. The HES program, for example, relies on a form of cost-benefit analysis to assess the <u>safety</u> benefits arising from capital expenditure. The required cost-benefit ratio is set to ensure that the HES program funds are used only where safety (as opposed to economic) benefits are substantial in relation to the expenditure.

The FETSIM program lays strict conditions for the methodology which must be followed in signal timing plan calculation. A rigid schedule is also identified for the completion of the work; this includes, however, staff training courses which is an agency benefit to be obtained from the program over-and-above the recognized community benefit of improved signal timings.

The FETSIM committee (chaired by Caltrans), which administers the program, prioritizes the applications in such a way as to give preference to "first-time" applications (i.e. FETSIM studies for intersections not previously the subject of a FETSIM study). In the past, this has effectively limited the application of FETSIM funds to such projects.

The County's WWV program takes an approach of setting up an agreement between the County and the City which prohibits the changing of signal timings without the consent of both agencies. The benefits to the City come in the form of upgraded and hence more reliable signal equipment, as well as the community benefit from the coordination of the signals.

Finally, an example of a program offering 100% funding in the realm of signal coordination is the Federal Highway Administration's Preferential Match program for traffic control systems.

The FHWA has operated several funding programs with differing levels of provision of matching funds. The majority of programs provide for up to 70% federal funds to match 30% local funds (70/30 funding). Two notable exceptions to this are the Interstate program which provided matched funding at a 90/10 level and the Traffic Control program which involved 100/0 funding. A drawback to this was that the 100% was equivalent to the more usual 70% in real terms, so the overall scope of the project was reduced. However, this was considered acceptable given the relaxation on the requirement for local funding.

4.2.2 Level of Funding

Concern has been expressed at Focus Group and Expert Panel meetings at the difficulty smaller cities have in appropriating matching funds to complement current programs such as the County's WWV program. Traffic issues are often overshadowed by more pressing and politically sensitive local issues and this may be exacerbated when Regional traffic issues are competing with other local issues for such limited funds.

Given this situation, it is felt that an objective of the program should be to provide 100% funding of approved, eligible projects. In the event that funding sources are limited to the extent that they are unable to support a large percentage of approved, eligible applications, then consideration should be given to a sliding-scale of degree of funding (e.g. from 100:0 to 50:50) dependent upon the priority/degree of importance of the project. This would also allow cities the opportunity to increase the possibility of a project's acceptance by contributing its own funds where practical.

In addition to the funding associated with capital and implementation costs, it is recommended that funding incentives also be available for operations and maintenance expenditure to reflect the goals of the countywide program. This would be funding provided to support any <u>increase</u> in operations and maintenance costs as a direct result of compliance with the program. Examples would be increased maintenance costs to comply with higher standards of maintenance set on a countywide basis and extra staff needed to support extended operations of a city's computer system to another jurisdiction.

Funding could start at 100% for the first year and be reduced to zero over a period of time to avoid the continued commitment on the part of the funding source. A five year period is suggested, with a 20% reduction (in terms of the initial funding) per year.

4.2.3. - Principles To Follow

The basic principles exemplified by the above mentioned programs can be summarized as follows:

1. Establish **criteria** to be used in the assessment/prioritization of applications.

2. Establish **guidelines** to be followed in the expenditure of funds and execution of the project.

3. Establish **agreements** for operation of any equipment purchased under the funding program.

4.2.3.1 - Criteria

An often repeated concern during the Focus Group meetings was the effort involved in simply applying for funding under such programs as HES and, to some extent, FETSIM. One objective to bear in mind when examining criteria for funding eligibility and distribution of funds, is to keep the application process simple and understandable. Hand-in-hand with this goes easily understandable selection criteria.

Key to criteria definition is the adherence to a single primary goal. The HES program's goal is safety improvement, the FETSIM program's fuel-efficient signal timings. The corresponding goal for the countywide program is congestion reduction through traffic signal synchronization. This is not to say that other objectives cannot be considered, but rather that anything else is secondary to the prime goal of improving traffic conditions.

Potential projects should, therefore, be prioritized according to their contribution to reducing congestion. Such a factor as Level of Service of affected facilities and intersections would be a key indicator or measure of effectiveness. Estimates of total delay would weigh-in the factor of the volume of traffic affected by a project, help in establishing the degree of impact (and hence "importance") of the project and so identify at least a level cost/benefit.

Other high priority items to be considered would then be safety aspects and type of existing equipment. The latter is important as a project should make a contribution to an overall program of equipment upgrading for improved reliability and reduced signal operations and maintenance costs.

The projects would be assessed against these primary and secondary factors to establish a "performance" rating and have a ranking. Such a ranking could also be used in establishing the degree of funding applicable (see section 4.2.1.1). Exhibit 4.1 shows how such an evaluation matrix would appear.

4.2.3.2 - Guidelines

The objective of specifying guidelines are to establish a degree of uniformity in various aspects of the execution of funded projects with the aim of reducing inefficiencies and expending funds in the most effective manner. Through the application of the guidelines, agencies can avoid having to go through the same learning curve and experiences suffered by other agencies.

This is particularly true in the procurement of signal control equipment. Much of the equipment in use today is specialist in nature and there are many pitfalls to avoid in specifying and purchasing such equipment.

Similarly, it may be wise to ensure that areas such as training and documentation are adequately covered. Finally, should it be applicable that, as a result of the funding, some form of agreement would be needed between concerned parties, then sample agreements should be given.

Exhibit 4-1 : Sample Criteria Evaluation Worksheet

Criteria		*Project Assessment*	
Measure	***Weight* (W)***	***Score (S)***	***Result (W)x(S)***
Level of Service A B C D E F			
Vehicle Hours of Delay per Day <200 200-2000 2000-5000 >5000			
Safety Improvements** Major Minor			
Intersection Upgrades Operational Benefits Maintenance Benefits			

* Weight to be assigned by technical staff
** To be determined

Typical issues to be addressed are:

a. Procurement

- regulations to follow

b. Equipment

- preferred types
- bulk purchase opportunities

c. Scope of Work

- minimum requirements for
  intersection upgrades
  training
  documentation

- schedules to follow

d. Sample Agreements

4.2.3.3 - Agreements

Working Paper 1 Part 4 - Review of Current Practices addressed the issue of suitable agreements which would be applicable under a countywide program. Examples are given in that report of such agreements and it is proposed that one of the tasks in Phase 2 of this project will be the development of sample agreements for use under the program.

One area which was found to be lacking in current similar agreements was that of consequences for **not** following the agreements. The consequences and suitable consequences in breaching such agreements. These will often be viewed as being punitive and so care must be taken in establishing a course of action commensurate with the degree to which an agreement or understanding has been violated.

Possible options include:

- pay-back of funds
- lower priority setting for future projects
- restriction of access to other facilities provided by the secretariat (see 4.3 below)

Whatever measures are defined, they will only be effective in ensuring further support for the program (and aid in the effectiveness of the program) if they can be easily enforced.

The consequences of not satisfying criteria for eligibility is obviously the rejection of the application. Similarly, if expenditure guidelines are not followed, then funding could be withheld by the body administering the program.

In the case of post-installation operations, a key aspect of the proposed countywide program, careful thought must be given to the successful maintenance of any operational agreement and suitable consequences in breaching such agreements.

4.3. SUPPORT SERVICES

Section 2 of this report has identified the role that a central secretariat can play in:

a. providing agencies with access to technical expertise
b. coordinating training programs
c. supporting the definition and development of new programs
d. providing an independent program audit capability
e. providing a forum for the peer review of schemes
f. applying for and administering funds

All these categories of support can provide tangible benefits for an agency wishing to make use of the features provided. Ready access to these capabilities should be seen as an incentive by agencies which will be enhanced by the promotion of the availability of these services.

The availability of funding is likely to dictate the degree to which agencies may have to pay for these services. As mentioned above (see section 4.2.1.3) restriction of access to and/or higher charges for these services could be punitive measure introduced to ensure compliance with conditions for funding and support of the program.

4.4 OTHER BENEFITS

4.4.1 - Program Association

It should be remembered success in implementing the program will lead to reduced congestion and a general improvement in the movement of traffic in the County through the association reduction in delay. Other attractive benefits include reduction in pollution and fuel consumption. Such resultant program benefits should be publicized wherever and whenever possible to stimulate interest in the program and generate support. Being associated with a successful program will improve credibility of an agency and enable the agency to carry out a degree of local promotion to demonstrate its own involvement.

There are obvious political benefits to be had as well as the simple building up of credibility of the agency with the public. The agency can present itself as representing local interest by being pro-active in regional or countywide programs in the sensitive area.

As the program gains momentum and support through suitable promotion and publication of successes, there will be a distinct incentive for an agency to become part of the countywide movement.

The following are recommended actions aimed at soliciting support for the countywide program:

- A public information campaign should be instigated which explains the program to the public and stresses the benefits to the road-user.

- A readily recognizable logo should be devised which can be used by agencies to indicate their involvement in the program.

- Active projects should be promoted in advance of construction. Upon, completion, benefits should be quantified and publicized.

- Training programs should be regularly advertised to agencies.

- Consideration should be given to the production of a regular newssheet/bulletin to publicize the program, its associated activities and successful projects.

4.4.2 - Maintenance

The program should, if successful, lead to improved operational and maintenance standards throughout the county. By being involved in the program, a city is presented with a guideline for the assessment of its equipment maintenance which can be particularly useful when such maintenance is contracted-out. In addition, the adoption of standard maintenance agreements will ensure that the City's risk liability is adequately covered. Such spin-offs are seen as attractive incentives to support the program.

It should be pointed out that an agency may lay itself open to a higher degree of risk if it does not react in a timely fashion following identification of problems in the maintenance area. However, it must be assumed that an agency will be willing to adopt any recommendations resulting from a review of its maintenance program.

4.5 NON-CITY AGENCIES

4.5.1 - General

Both the County of Los Angeles and the California Department of Transportation (Caltrans) already play major roles in traffic signal operations and maintenance and act as a funding agencies. Examples of this are, in the case of the County, the WWV program, and in the case of Caltrans, the FETSIM program and administering the FAU program. It is especially important for the success of the countywide program that these two agencies support the countywide program. Given this, it is worthwhile to examine incentives specifically with respect to these two agencies.

4.5.2 - The County of Los Angeles

The County is already active in improving signal synchronization on a countywide basis. However, its programs are, at times, frustrated in their implementation by conflicting local interests. The County's activities can only benefit from the proposed program's regional approach to establishing signal schemes across jurisdictional boundaries. The various forums proposed would provide the County with the opportunity to present its policies to the cities and get feedback to help formulate future programs. This is seen as a much more staff resource-effective way of liaising with the cities than the current organization which only provides for city contacts on a one-to-one basis.

As a proponent of equipment modernization and standardization, the County would see its policies in these areas being much more effectively carried out. This will eventually allow the County maintenance staff to provide a much more efficient service (on a per capita basis) as the equipment base is upgraded and made inherently more reliable. County staff have expressed concern at cities becoming dependent upon a single manufacturer for its signal control equipment. As explained in section 2, the potential of bulk equipment purchase as part of an equipment standardization program would help cities avoid such a situation.

The County shares the same problems as smaller agencies with respect to staffing in terms of availability of skilled personnel for operations and maintenance, and so would benefit from the proposed training courses organized by the signals secretariat. In the same way, the County could draw upon the technical resource pool to satisfy the need for specialist expertise in those areas where the County lacks resources.

Finally, it is likely that a concerted, coordinated approach to traffic signal improvement schemes is likely to maximize the benefit to be obtained from any funds made available at the local level. The association of the County with the efficient, effective use of local funds can only be beneficial to the County's public image and help in gaining public acceptance and support for future programs.

4.5.3 - Caltrans

As part of the countywide program, Caltrans could take advantage of the multi-agency coordination aspects of the program to establish a more integrated approach to freeway and arterial operations. The prime example of this is currently the Santa Monica Smart Corridor project in which Caltrans and the City of Los Angeles are playing active roles.

A regional approach to operating a coordinated network would complement Caltrans' operations, and make State highways more efficient in terms of moving traffic during peak periods. In turn, such schemes position the State well when applying for potential funding under the proposed Traffic Systems Management and Congestion Management Programs.

As the State transportation agency, Caltrans has long been active in promoting statewide standards for traffic signal control equipment. Through active participation in the program, such standards can be promoted. In addition, as has been proven with the regular maintenance staffing meetings between Caltrans and several cities, the Cities themselves have much to contribute in improving and adapting such specifications to the ever-changing technology in use in traffic control.

Caltrans shares similar policies to those of the County with respect to traffic control equipment standardization, especially with respect to controllers where Caltrans promotes the use of Type 170 controller.

Caltrans is most aware that, as a State agency it cannot operate effectively without suitable cooperation and coordination with local agencies. The countywide program provides a real opportunity to strengthen such ties and improve inter-agency relationships.

4.6 FINDINGS AND RECOMMENDATIONS

4.6.1 - Findings

It is envisioned that there will be several potential incentives to encourage support of the program by the agencies operating within the County. These include:

- o Funding of projects to upgrade controllers and install coordination equipment
- o Access to support services
- o Community benefits accruing from the successful implementation of projects under the program

- o Promotion of current agency policies and increased awareness/acceptance at the local level
- o The opportunity for integrated operations of the freeway and arterial networks
- o Access to training programs and eventually availability of more trained staff
- o Improved public image

4.6.2 - Recommendations

The following recommendations have emerged with regard to providing incentives for the countywide program:

- o Funding should be provided for capital and implementation projects associated with the program.
- o Capital and implementation funding support should be provided at a 100% level with a sliding-scale of reduced funding should limited funds be available.
- o Funding should be provided for increased operations and maintenance costs resulting from actions under the program. This should start at the 100% level and decrease to zero over a period of five years starting at implementation.
- o The process for applying for funds should be simple to avoid being resource intensive.
- o Measures should be devised and followed to be enacted should funding conditions be violated.
- o An active promotional campaign should be instigated to solicit support for the program and ensure public awareness.

5. SUMMARY OF FINDINGS AND RECOMMENDATIONS

The Phase One study into traffic signal synchronization, operation and maintenance in the County of Los Angeles has found that the majority of cities, the County Department of Public Works and the California Department of Transportation (Caltrans) agree that it is feasible to proceed with a countywide program to introduce improvements in these areas. There is a clear consensus for the proposal of introducing a Signals Secretariat to act in a coordination and supportive role and for having a regional structure introduced under which inter-jurisdictional traffic signal operations and maintenance can function.

It is clear that local agencies have strong concerns about their roles in area-wide programs but are supportive of a regional approach to traffic signal management. In particular, there is widespread support for the identification of a distinct major arterial network and developing operational policies to improve traffic conditions on these facilities.

Agencies have consistently expressed their desire to retain some control over their signals to ensure that local, as well as area concerns, are addressed. This concern, as well as the fact that several agencies have begun or are already implementing new systems, has strongly influenced the direction of this program.

5.1 SUMMARY OF FINDINGS

The following is a summary of the findings of that section of the study which has examined the organizational and institutional issues associated with the program. This included an assessment of the current signal operations in the County.

- Area-wide coordination is needed and will benefit all motorists Countywide.
- No single, central based system will meet all the needs of every local jurisdiction and such a system would not receive the local support needed for successful implementation.
- There are subregions within the County that exhibit strong identities created by natural boundaries or historical association that lend themselves for coordinating the operation of traffic signals.
- Local agencies have expressed a need for information, technical support, training and educational programs to facilitate the synchronization, operation and maintenance of their traffic signals.

- Uniform standards of operations and maintenance are needed. This need includes standardizing maintenance agreements and guidelines, establishing procurement guidelines for contract maintenance, standardizing cooperative agreements between adjacent cities and establishing technical and performance standards.

- A major benefit of a regional program would be the reduction of traffic congestion on major arterial streets and highways, the reduction of the associated environmental impacts, and the reduction in use of local residential streets by traffic bypassing congested major streets.

- Additional funding sources for such a countywide program are in the process of being prepared for voting on by the public.

The following findings have resulted from that part of the study which has examined the technical issues associated with traffic signal operations in the County:

- A single central traffic control system is not a viable option given the levels of diverse equipment invested in the County, the pursuance and justification of different but appropriate technical paths at the local level and the lack of consensus support for such an option.

- The diversity of equipment is such that there exists no single, optimum equipment/technical approach or option applicable countywide.

- Pursuance of Alternative R2 where applicable would require capital expenditure of approximately $365 million and result in increases in operational and maintenance costs of approximately $3 million per annum. (All estimates are in current dollars.)

- Pursuance of Alternative R5 (covering intersections on arterials in the County) would require capital expenditure of approximately $275 million and result in increases in operational and maintenance costs of approximately $2.5 million per annum. (All estimates are in current dollars.)

- Each city would need to be assessed individually and as part of its region to establish which of the technical options would be most applicable. This study would need to take into account the operational and maintenance requirements of the agencies involved.

- The application of WWV technology is appropriate for providing coordination between individual intersections and between systems.

- Where coordination equipment has to support operations and maintenance activities, then two-way coordination is needed.

- Agencies need not surrender any degree of control or give another agency any degree of control by connecting its signal equipment to that agency's system.

It is envisioned that there will be several potential incentives to encourage support of the program by the agencies operating within the County. These include:

- Funding of projects to upgrade controllers and install coordination equipment

- Access to support services

- Community benefits accruing from the successful implementation of projects under the program

- Promotion of current agency policies and increased awareness/acceptance at the local level

- The opportunity for integrated operations of the freeway and arterial networks

- Access to training programs and eventually availability of more trained staff

- Improved public image

5.2 SUMMARY OF RECOMMENDATIONS

The following recommendations have been formed on the basis of the analysis of organizational issues:

- A countywide program should emphasize a regional concept with coordination policies set by the local agencies in each region and should, as a minimum, address the major arterials in the County.

- A Signals Secretariat should be establish to provide regional support. This entity would provide needed technical support, training and other functions as identified by the local agencies. The Secretariat would also secure and distribute funds under the program.

- o The location of the Signals Secretariat should be determined by TRAFFIC and have permanent staff associated with it.

- o The Signals Secretariat should be established in time to prepare programs to take advantage of any funding that becomes available in 1990 and has been identified for use in transportation.

- o Two Steering Committees should be established to set and monitor overall policies. One should be made up of technical agency staff, voted on to the Technical Committee. The second should be made up of elected members, voted to serve on the Elected Representatives Committees.

Section 2.6 presents the findings associated with the analysis of the organizational and institutional issues. These include the support identified for arterial coordination. Taking into account this and the above findings, the following recommendations are made:

- o The countywide program should be based upon the regional application of systems employing two-way communications with street equipment for the support of operations and maintenance. When such support is not required, then the preferred means of coordinating intersections should be using WWV technology.

- o Where groups of intersections are involved, the countywide program should include the application of WWV technology to coordinate systems.

- o A prime task of the Signals Secretariat should be the initiation of a program to assess the regional equipment requirements on the basis of the information presented in this study.

The following recommendations have emerged with regard to providing incentives for the countywide program:

- o Funding should be provided for capital and implementation projects associated with the program.

- o Capital and implementation funding support should be provided at a 100% level with a sliding-scale of reduced funding should limited funds be available.

- o Funding should be provided for increased operations and maintenance costs resulting from actions under the program. This should start at the 100% level and decrease to zero over a period of five years starting at implementation.

- o The process for applying for funds should be simple to avoid being resource intensive.

Measures should be devised and followed to be enacted should funding conditions be violated.

- o An active promotional campaign should be instigated to solicit support for the program and ensure public awareness.

APPENDIX A

CAPITAL AND IMPLEMENTATION COST MATRICES

Cost Matrices Items

	Item		Total
1	New NEMA controller in cabinet		$6,500
2	New Type 170 controller in cabinet		$6,500
3	Proprietary controller		
	(with system capability)		$8,000
4	Communication module Type 170		$500
5	Remote Communications Unit (RCU)		
	(includes termination panel)		$2,000
6	Interconnect cable		
	(existing conduit)		
	Closed Loop (1/4 mile @ approx. $1/foot)		$1,500
	Centralized system (1/4 mile @ approx. $1/foot)		$2,500
7	Interconnect cable		
	(new conduit, City of Los Angeles budget item)		$20,000
8	Loops (System Detectors)		
	(City of Los Angeles Budget item)		$7,500
9	Closed Loop Master		
	(in cabinet with a controller)		
	average of 10 intersections per master		
	$5000 per master+$2000 per master dial-up connect		
	cost per intersection		$700
10	SETCOM TR 600		
	Unit	$2,693	
	Harness	$115	
	Power Cord	$30	
	Antenna	$185	
	Sub total	$3,023	
	Installation/contingency	$477	
	Total		$3,500
11	BiTrans Quicnet central computer		$25,000
12	Data Channel		
	Connection	$2,528	
	Monthly	$518	
	10 year cost	$64,688	
	cost per intersection (6 int/channel)		$10,781
13	T1 Channel		
	Multiplexing equipment	$100,000	
	T1 channel connection	$1,240	
	10 year rental @ $142/month	$17,040	
	10 year cost		$118,280

Cost Matrices Items

Item			Total
14	Traconex WWV module		
	Model 1010 (quantity price)	$500	
	Power Supply	$95	
	Opto-isolator	$95	
	RS232 cable	$45	
	antenna	$95	
	sub-total	$830	
	installation	$370	
	total		$1,200
15	Time Source WWV unit		
	Model 1020	$1,210	
	Installation	$290	
	Total		$1,500
16	CTL Coordinated Time Link		
	CTS-10 with software	$200	
	installation/software mods	$800	
	Total		$1,000

Cost Build-Up Matrices

Item : **1A : Coordinating Intersections via Time-Based Coordination**

Existing Controller	New Components (per intersection)						Total
	New Cont.	Int. Upgrade	Loops	Integration	External TBC+WWV	WWV Module	
E-M pre-timed	$6,500	$10,000	$7,500	$9,000		$1,200	$34,200
SS pre-timed			$7,500	$6,000	$3,500		$17,000
NEMA			$7,500	$6,000	$3,500		$17,000
Type 170			$7,500	$4,500		$1,200	$13,200
Other	$6,500	$10,000	$7,500	$9,000		$1,200	$34,200

Comments : * 1) Assumes new controllers are Type 170 with appropriate LACO firmware

2) No "Per System" Costs

Cost Build-Up Matrices

Item : **1B : Incorporate Intersections into a System**

(i) Type 170 Closed Loop System

Existing Controller	New Components (per intersection)							Total
	170 Controller	Comm. Module	Int. Upgrade	Field Master	Loops	Inter-connect	Integration	
E-M pre-timed	$6,500	$500	$10,000	$700	$7,500	$20,000	$10,500	$55,700
SS pre-timed	$6,500	$500		$700	$7,500	$20,000	$7,500	$42,700
NEMA	$6,500	$500		$700	$7,500	$20,000	$7,500	$42,700
Type 170		$500		$700	$7,500	$20,000	$6,000	$34,700
Other	$6,500	$500	$10,000	$700	$7,500	$20,000	$10,500	$55,700

Per System Costs :

Remote Terminal Interface Central PC Assembly w/ software, printer, and modem	$25,000
170 Firmware License	$8,500
Total	$33,500

Cost Build-Up Matrices

Item : **1B : Incorporate Intersections into a System**

(ii) NEMA-Based Closed Loop System

Existing Controller	New Components (per intersection)						Total
	Proprietary Controller	Int. Upgrade	Field Master	Loops	Inter-connect	Integration	
E-M pre-timed	$8,000	$10,000	$700	$7,500	$20,000	$10,500	$56,700
SS pre-timed	$8,000		$700	$7,500	$20,000	$7,500	$43,700
NEMA	$8,000		$700	$7,500	$20,000	$7,500	$43,700
Type 170	$8,000		$700	$7,500	$20,000	$7,500	$43,700
Other	$8,000	$10,000	$700	$7,500	$20,000	$10,500	$56,700

Per System Costs

Remote Terminal Interface Central PC Assembly w/ software, printer, and modem	$25,000
Total	$25,000

Cost Build-Up Matrices

Item : **1B : Incorporate Intersections into a System**

(iii) Multisonics VMS System

Existing Controller	New Components (per intersection)						Total
	Proprietary Controller	Remote Comm. Unit	Int. Upgrade	Loops	Inter-connect	Integration	
E-M pre-timed	$8,000		$10,000	$7,500	$20,000	$11,000	$56,500
SS pre-timed		$2,000		$7,500	$20,000	$8,000	$37,500
NEMA		$2,000		$7,500	$20,000	$8,000	$37,500
Type 170				$7,500	$20,000	$8,000	$35,500
Other	$8,000		$10,000	$7,500	$20,000	$11,000	$56,500

Per System Cost

Remote Terminal Interface	Terminal with printer and modem	$5,000
Software License		$25,000
Type 170 Firmware License		$8,500
	Total	$38,500

Cost Build-Up Matrices

Item : **1B : Incorporate Intersections into a System**

(iv) UTCS (ATSAC) System

Existing Controller	New Components (per intersection)						Total
	170 Controller	Int. Upgrade	Comm Module	Loops	Inter-connect	Integration	
E-M pre-timed	$6,500	$15,000	$500	$7,500	$20,000	$14,000	$63,500
SS pre-timed	$6,500	$5,000	$500	$7,500	$20,000	$11,000	$50,500
NEMA	$6,500	$5,000	$500	$7,500	$20,000	$11,000	$50,500
Type 170		$5,000	$500	$7,500	$20,000	$9,500	$42,500
Other	$6,500	$15,000	$500	$7,500	$20,000	$14,000	$63,500

Per System Costs

Remote Terminal Interface PC workstation with printer, modem, and high-resolution graphics		$25,000
Software Modifications (Access restrictions for remotes)		$10,000
170 Firmware License		$8,500
Central Software License		$25,000
Graphics Software License		$8,000
	Total	$76,500

Cost Build-Up Matrices

Item : 1B : **Incorporate Intersections into a System**

(v) Centralized Distributed System

Existing Controller	New Components (per intersection)							Total
	170 Controller	Remote Comm unit	Comm Module	Int. Upgrade	Loops	Inter-connect	Integration	
E-M pre-timed	$6,500		$500	$10,000	$7,500	$20,000	$11,000	$55,500
SS pre-timed		$2,000			$7,500	$20,000	$7,000	$36,500
NEMA		$2,000			$7,500	$20,000	$7,000	$36,500
Type 170			$500		$7,500	$20,000	$5,500	$33,500
Other	$6,500		$500	$10,000	$7,500	$20,000	$11,000	$55,500

Per System Costs

Remote Terminal Interface PC workstation with modem, printer, and high-resolution graphics	$25,000
Central Software License	$25,000
RCU Firmware License	$5,000
170 Firmware License	$8,500
Graphics Software License	$8,000
Total	**$71,500**

Cost Build-Up Matrices

Item : **2A : Common Time-Base between Systems**

System Type	New Components (per system) WWV Time Reference	Total
Arterial Master (170)	WWV module installed at Type 170 master	$1,200
Arterial Master (Other)	SETCON model TR-600 installed at master	$3,500
Closed Loop	CTL-WWV board/software installed in central PC	$1,000
Multisonics VMS	VAX Time Source at central w/ software mods.	$10,000
UTCS (ATSAC)	Existing	$0
Central'd Distributed	VAX Time Source at central w/ software mods.	$1,500

Comments : No Per Intersection Costs

Cost Build-Up Matrices

Item : **2B : Incorporate Sytem A into System B**

(i) System B is Closed Loop

System A	New Components (per intersection)						Total
	New Controller*	Int. Upgrade	Field Master	Loops	Inter-connect	Integration	
Arterial Master (170)			$200	$7,500	$1,500	$1,400	$10,600
Arterial Master (Other)	$7,000	$10,000	$700	$7,500	$1,500	$5,600	$32,300

Comments : * Assumes closed loop system is Type 170 based

Per System Costs :

Remote Terminal Interface

Central PC Assembly w/software, printer, and modem	$25,000
170 Firmware License	$8,500
Total	$33,500

Cost Build-Up Matrices

Item : 2B : Incorporate Sytem A into System B

(ii) System B is Multisonics VMS

System A	New Components (per Intersection)						Total
	New 820 Controller	Int. Upgrade	Loops	Data Channel*	Inter-connect	Integration	
Arterial Master (170)	**		$7,500	$3,000	$2,500	$4,000	$17,000
Arterial Master (Other)	$8,000	$10,000	$7,500	$3,000	$2,500	$4,000	$35,000

Comments : * Capital costs only - Annual charges not included
** Software change only

Per System Costs :

Remote Terminal Interface Terminal with printer and modem and modem	$25,000
Central Software License	$25,000
Total	$50,000

Cost Build-Up Matrices

Item : **2B : Incorporate System A into System B**

(iii) System B is UTCS (ATSAC)

System Type	New Components (per intersection)							Total
	170 Controller	Comm. Module	Int. Upgrade	Data Channel	Loops	Inter-connect	Integration	
Arterial Master (170)		$500	$5,000	$500	$7,500	$20,000	$10,500	$44,000
Arterial Master (Other)170	$6,500	$500	$15,000	$500	$7,500	$20,000	$7,500	$57,500
Closed Loop (170)			$5,000	$500	$7,500	$20,000	$7,500	$40,500
Closed Loop (Other)	$6,500	$500	$5,000	$500	$7,500	$20,000	$6,000	$46,000
Multisonics VMS	$6,500	$500	$5,000	$500	$7,500	$20,000	$10,500	$50,500

System Type	New Components (per system)					Total
	Software License	Graphics License	170 Firmw. License	Remote Terminal Interface	T1 Channel and Multiplexing Eqpt.	
Arterial Master (170)	$25,000	$8,000	$8,500	$25,000		$66,500
Arterial Master (Other)170	$25,000	$8,000	$8,500	$25,000		$66,500
Closed Loop (170)	$25,000	$8,000	$8,500	$25,000		$66,500
Closed Loop (Other)	$25,000	$8,000	$8,500	$25,000		$66,500
Multisonics VMS	$25,000	$8,000	$8,500	$25,000	$100,000	$166,500

Cost Build-Up Matrices

Item : 2B : Incorporate System A into System B

(iv) System B is Centralized Distributed

System Type	New Components (per intersection)								Total
	170 Controller	Int. Upgrade	Comm. Module	RCU	Loops	Inter-connect	Data Channel	Integration	
AM (170)			$500		$7,500	$2,500	$3,000	$2,400	$15,900
AM (other)	$6,500	$10,000	$500		$7,500	$2,500	$3,000	$6,500	$36,500
CL (170)					$7,500	$2,500	$3,000	$2,400	$15,400
CL (Other)				$2,000	$7,500	$2,500	$3,000	$2,600	$17,600
VMS				$2,000	$7,500			$1,500	$11,000

System Type	New Components (per system)						Total
	Software License	Graphics License	170 Firmw. License		Remote Terminal Interface	T1 Channel and Multiplexing Eqpt.	
AM (170)	$25,000	$8,000	$8,500		$25,000		$66,500
AM (other)	$25,000	$8,000	$5,000		$25,000		$63,000
CL (170)	$25,000	$8,000	$8,500		$25,000		$66,500
CL (other)	$25,000	$8,000	$5,000		$25,000		$63,000
VMS	$25,000	$8,000	$5,000		$25,000	$100,000	$163,000

Cost Build-Up Matrices

Item : **2C : Incorporate Sytem A and/or B into New System**

(i) New System is Closed Loop

System A	New Components (per intersection)						Total
	New Controller*	Int. Upgrade	Field Master	Loops	Inter-connect	Integration	
Arterial Master (170)			$200	$7,500	$1,500	$1,400	**$10,600**
Arterial Master (Other)	$7,000	$10,000	$700	$7,500	$1,500	$5,600	**$32,300**

Comments : * Assumes closed loop system is Type 170 based with dial-up between the central and the master.

Per System Costs :

Central System

Central PC Assembly w/software, printer, and modem	$25,000
170 Firmware License	$8,500
Total	**$33,500**

Cost Build-Up Matrices

Item : 2C : Incorporate System A and/or System B into New System

(ii) New System is Centralized

System Type	New Components (per intersection)								Total
	170 Controller	Int. Upgrade	Comm. Module	RCU	Loops	Inter-connect	Data Channel	Integration	
AM (170)			$500		$7,500	$2,500	$3,000	$2,400	$15,900
AM (other)	$6,500	$10,000	$500		$7,500	$2,500	$3,000	$6,500	$36,500
CL (170)					$7,500	$2,500	$3,000	$2,400	$15,400
CL (Other)				$2,000	$7,500	$2,500	$3,000	$2,600	$17,600
VMS				$2,000	$7,500			$1,500	$11,000

System Type	New Components (per system)								Total
	Software License	Graphics License	170 Firmw. License	Central Equipment					
AM (170)	$25,000	$8,000	$8,500	$250,000					$291,500
AM (other)	$25,000	$8,000	$5,000	$250,000					$288,000
CL (170)	$25,000	$8,000	$8,500	$250,000					$291,500
CL (other)	$25,000	$8,000	$5,000	$250,000					$288,000
VMS	$25,000	$8,000	$5,000	$250,000					$288,000

APPENDIX B

OPERATING COST SUMMARIES

Operational Cost Matrix

Alternative R2 (p1)

System Element	Cost	Agoura/Westlake		Antelope Valley		Central/Western		Harbor		Pomona		San Fernando	
		Units	Extension	Units	Extension	Units	Extension	Units	Extension	Units	Extension	Units	Extension
Closed Loop													
Central Equipment													
Maintenance	$2,500	2	$5,000	2	$5,000		$0		$0	1	$2,500	1	$2,500
Line Rental (per year)	$360	2	$720	2	$720	2	$720		$0	1	$360	2	$720
Line Maintenance (per intersection)	$400	21	$8,400	88	$35,200	101	$40,400		$0	100	$40,000	29	$11,600
Centralized													
Central Equipment	$10,000		$0		$0	2	$20,000	2	$20,000		$0	1	$10,000
Remote Terminals													
Equipment	$2,500		$0		$0	2	$5,000	8	$20,000		$0	1	$2,500
Line Rental (per year)	$6,204		$0		$0	2	$12,408	8	$49,632		$0	1	$6,204
Line Maintenance (per intersection)	$400		$0		$0	283	$113,200	886	$354,400		$0	133	$53,200
Staff	$100,000		$0		$0	2	$200,000	2	$200,000		$0	1	$100,000
Total			$14,120		$40,920		$391,728		$644,032		$42,860		$186,724
Total (all regions)			$3,079,008										

(Costs are increases over current costs and exclude the Cities of Pasadena and Los Angeles)

***includes County terminals**

Operational Cost Matrix   Alternative R2 (p2)

System Element	Cost	San Gabriel(E)		San Gabriel(W)*		Santa Clarita		South Bay		South East		Totals	
		Units	Extension	Units	Extension	Units	Extension	Units	Extension	Units	Extension	Units	Extension
Closed Loop													
Central Equipment													
Maintenance	$2,500	7	$17,500	4	$10,000	1	$2,500	1	$2,500	1	$2,500	20	$50,000
Line Rental (per year)	$360	12	$4,320	2	$720	1	$360	3	$1,080	1	$360	28	$10,080
Line Maintenance (per intersection)	$400	96	$38,400	51	$20,400	38	$15,200	106	$42,400	29	$11,600	659	$263,600
Centralized													
Central Equipment	$10,000		$0	2	$20,000		$0	2	$20,000	3	$30,000	12	$120,000
Remote Terminals													
Equipment	$2,500		$0	7	$17,500		$0	6	$15,000	8	$20,000	32	$80,000
Line Rental (per year)	$6,204		$0	7	$43,428		$0	6	$37,224	8	$49,632	32	$198,528
Line Maintenance (per intersection)	$400		$0	454	$181,600		$0	477	$190,800	659	$263,600	2892	$1,156,800
Staff	$100,000		$0	2	$200,000		$0	2	$200,000	3	$300,000	12	$1,200,000
Total			$60,220		$493,648		$18,060		$509,004		$677,692		$3,079,008
Total (all regions)			$3,079,008										

(Costs are increases over current costs and exclude the Cities of Pasadena and Los Angeles)

*includes County terminals

Operational Cost Matrix

Alternative R5 (p1)

System Element	Cost	Agoura/Westlake		Antelope Valley		Central/Western		Harbor		Pomona		San Fernando	
		Units	Extension	Units	Extension	Units	Extension	Units	Extension	Units	Extension	Units	Extension
Closed Loop													
Central Equipment Maintenance	$2,500	2	$5,000	2	$5,000		$0		$0	1	$2,500	1	$2,500
Line Rental (per year)	$360	2	$720	2	$720	2	$3		$0	1	$360	2	$720
Line Maintenance (per intersection)	$400	21	$8,400	61	$24,400	33	$45		$0	62	$24,800	26	$10,400
Centralized													
Central Equipment	$10,000		$0		$0	2	$20,000	2	$20,000		$0	1	$10,000
Remote Terminals Equipment	$2,500		$0		$0	2	$5,000	8	$20,000		$0	1	$2,500
Line Rental (per year)	$6,204		$0		$0	2	$12,408	8	$49,632		$0	1	$6,204
Line Maintenance (per intersection)	$400		$0		$0	180	$72,000	712	$284,800		$0	110	$44,000
Staff	$100,000		$0		$0	2	$200,000	2	$200,000		$0	1	$100,000
Total			$14,120		$30,120		$309,456		$574,432		$27,660		$176,324
Total (all regions)			$2,743,660										

(Costs are increases over current costs and exclude the Cities of Pasadena and Los Angeles)

***includes County terminals**

Operational Cost Matrix — Alternative R5 (p2)

System Element	Cost	San Gabriel(E)		San Gabriel(W)*		Santa Clarita		South Bay		South East		Totals	
		Units	Extension	Units	Extension	Units	Extension	Units	Extension	Units	Extension	Units	Extension
Closed Loop													
Central Equipment													
Maintenance	$2,500	7	$17,500	11	$27,500	1	$2,500	1	$2,500	1	$2,500	27	$67,500
Line Rental (per year)	$360	10	$3,600	9	$3,240	1	$360	2	$720	1	$360	32	$11,520
Line Maintenance (per intersection)	$400	242	$96,800	232	$92,800	38	$15,200	81	$32,400	29	$11,600	825	$330,000
Centralized													
Central Equipment	$10,000		$0	2	$20,000		$0	2	$20,000	3	$30,000	12	$120,000
Remote Terminals													
Equipment	$2,500		$0	3	$7,500		$0	6	$15,000	8	$20,000	28	$70,000
Line Rental (per year)	$6,204		$0	3	$18,612		$0	6	$37,224	8	$49,632	28	$173,712
Line Maintenance (per intersection)	$400		$0	98	$39,200		$0	353	$141,200	509	$203,600	1962	$784,800
Staff	$100,000		$0	2	$200,000		$0	2	$200,000	3	$300,000	12	$1,200,000
Total			$117,900		$408,852		$18,060		$449,044		$617,692		$2,757,532
Total (all regions)			$2,743,660										

(Costs are increases over current costs and exclude the Cities of Pasadena and Los Angeles)
***includes County terminals**

APPENDIX C

REGIONS

LOS ANGELES COUNTYWIDE
TRAFFIC SIGNAL SYNCHRONIZATION, OPERATION AND MAINTENANCE PROGRAM

PROPOSED REGIONS

<u>CENTRAL/WESTERN REGION</u>

Beverly Hills
Culver City
Los Angeles (central, south-central, westside areas)
Santa Monica
West Hollywood
County unincorporated (Ladera Heights, Malibu, Marina del Rey areas)

<u>SOUTH BAY REGION</u>

El Segundo
Gardena
Hawthorne
Hermosa Beach
Inglewood
Lawndale
Lomita
Los Angeles (LAX, Westchester areas)
Manhattan Beach
Palos Verdes Estates*
Rancho Palos Verdes
Redondo Beach
Rolling Hills
Rolling Hills Estates
Torrance
County unincorporated (Athens, El Camino College, Lennox areas)

<u>HARBOR REGION</u>

Artesia
Bellflower
Carson
Cerritos
Compton
Hawaiian Gardens
Lakewood
Long Beach
Los Angeles (harbor strip, San Pedro, Wilmington areas)
Paramount
Signal Hill
County unincorporated (Dominguez, Willowbrook areas)

SOUTHEAST REGION

Bell
Bell Gardens
Commerce
Cudahy
Downey
Huntington Park
La Habra Heights
La Mirada
Lynwood
Maywood
Montebello
Norwalk
Pico Rivera
Sante Fe Springs
South Gate
Vernon
Whittier
County incorporated (Florence, South Whittier areas)

WEST SAN GABRIEL REGION

Alhambra
Arcadia
Bradbury*
Duarte
El Monte
Monrovia
Monterey Park
Pasadena
Rosemead
San Gabriel
San Marino
Sierra Madre*
South El Monte
South Pasadena
Temple City
County unincorporated (Altadena, City Terrace, East Los Angeles, Whittier Narrows areas)

EAST SAN GABRIEL REGION

Azusa
Baldwin Park
Covina
Diamond Bar
Glendora
Industry
Irwindale
La Puente
Walnut
West Covina
County unincorporated (Bassett, Covina Hills, Hacienda Heights, Valinda areas)

POMONA VALLEY REGION

- Claremont
- La Verne
- Pomona
- San Dimas
- County unincorporated (Cal Poly Pomona area)

SAN FERNANDO VALLEY REGION

- Burbank
- Glendale
- Hidden Hills*
- La Canada Flintridge
- Los Angeles (San Fernando Valley, Tujunga areas)
- San Fernando
- County unincorporated (Calabasas, La Crescenta, Universal City areas)

AGOURA/WESTLAKE REGION

- Agoura Hills
- Westlake Village
- County unincorporated (Las Virgenes area)

SANTA CLARITA REGION

- Santa Clarita
- County unincorporated

ANTELOPE VALLEY REGION

- Lancaster
- Palmdale
- County unincorporated (Four Points, Quartz Hill, other areas)

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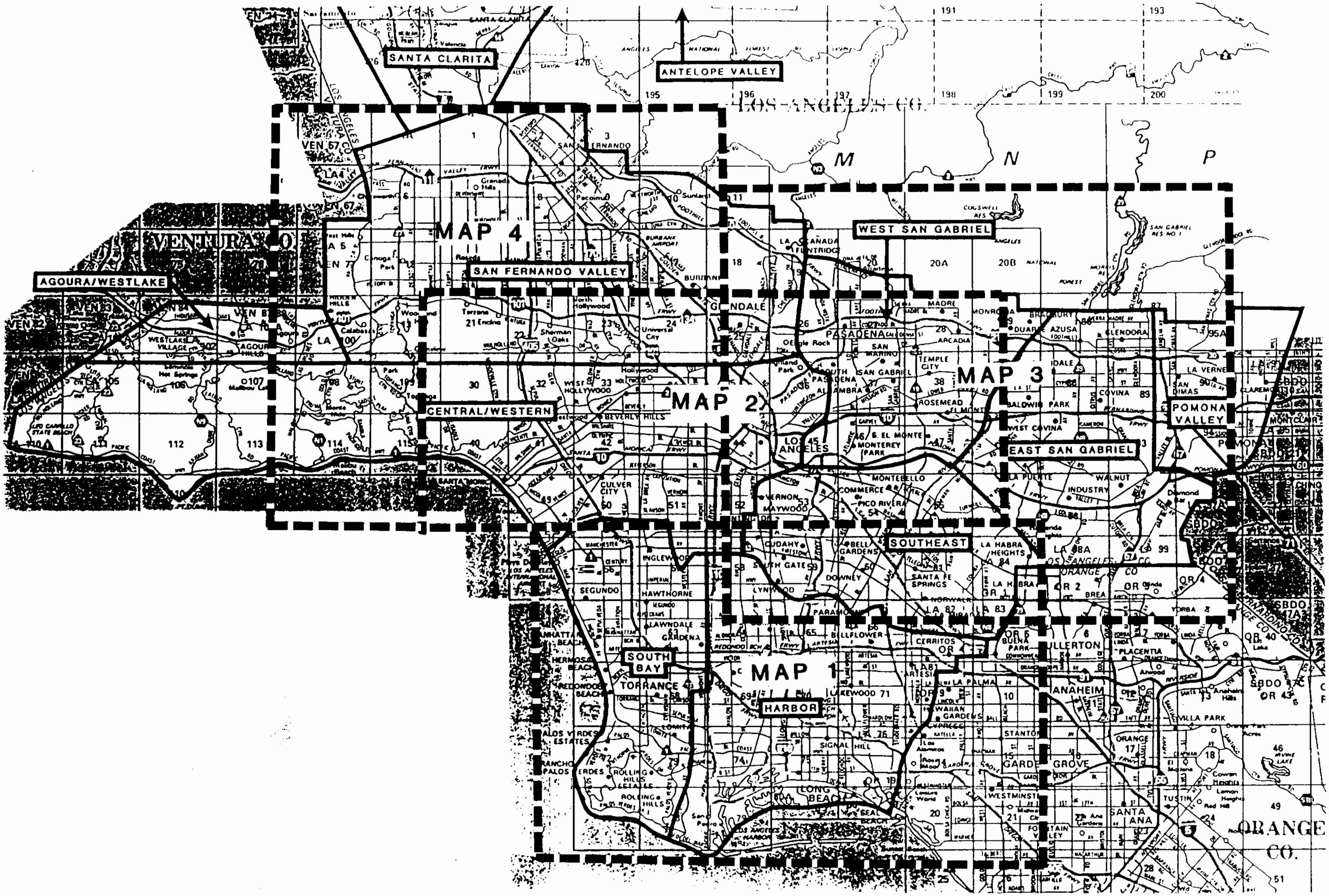
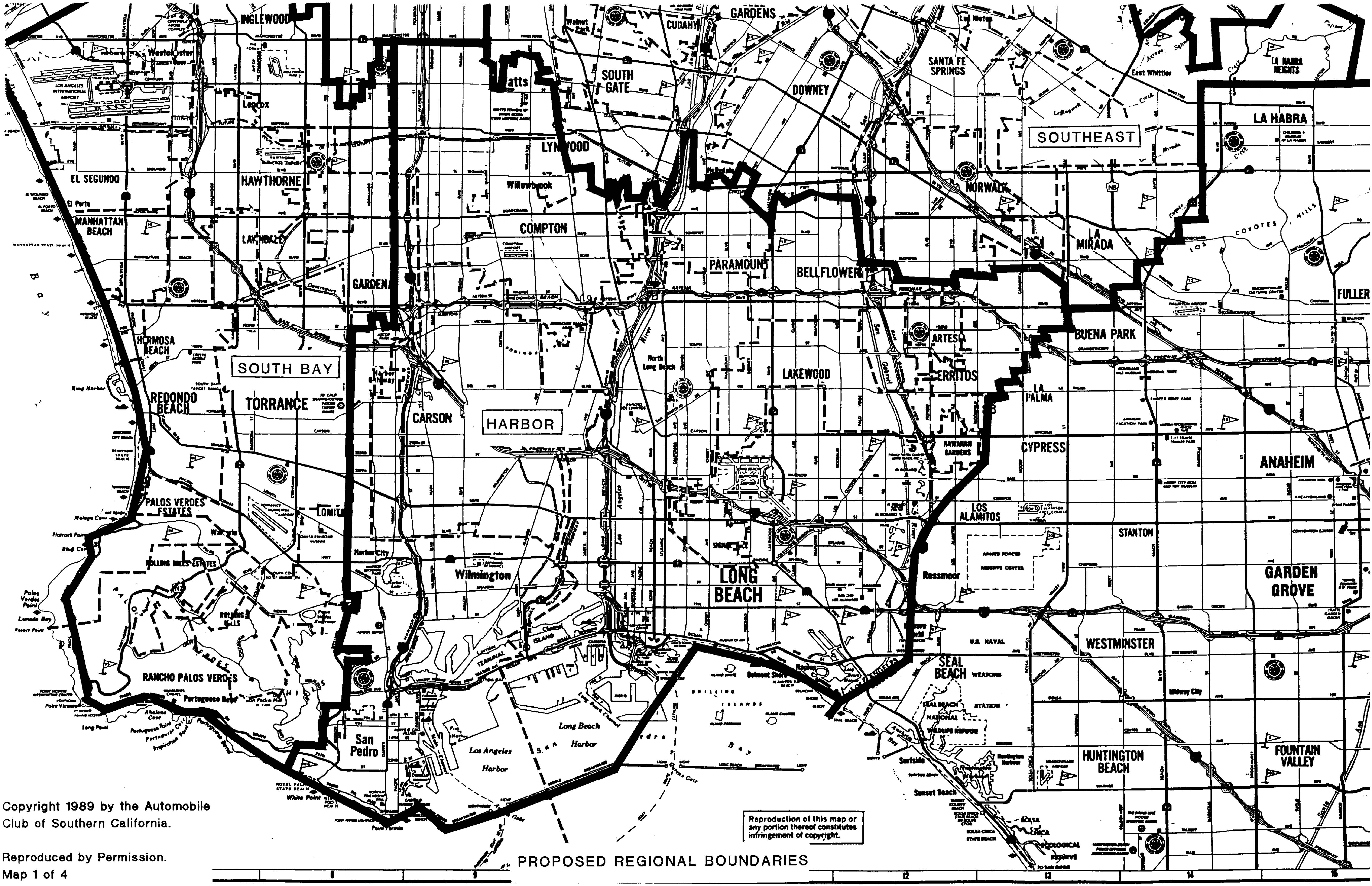
* indicates no traffic signals in city



KEY MAP TO PROPOSED REGIONAL BOUNDARIES



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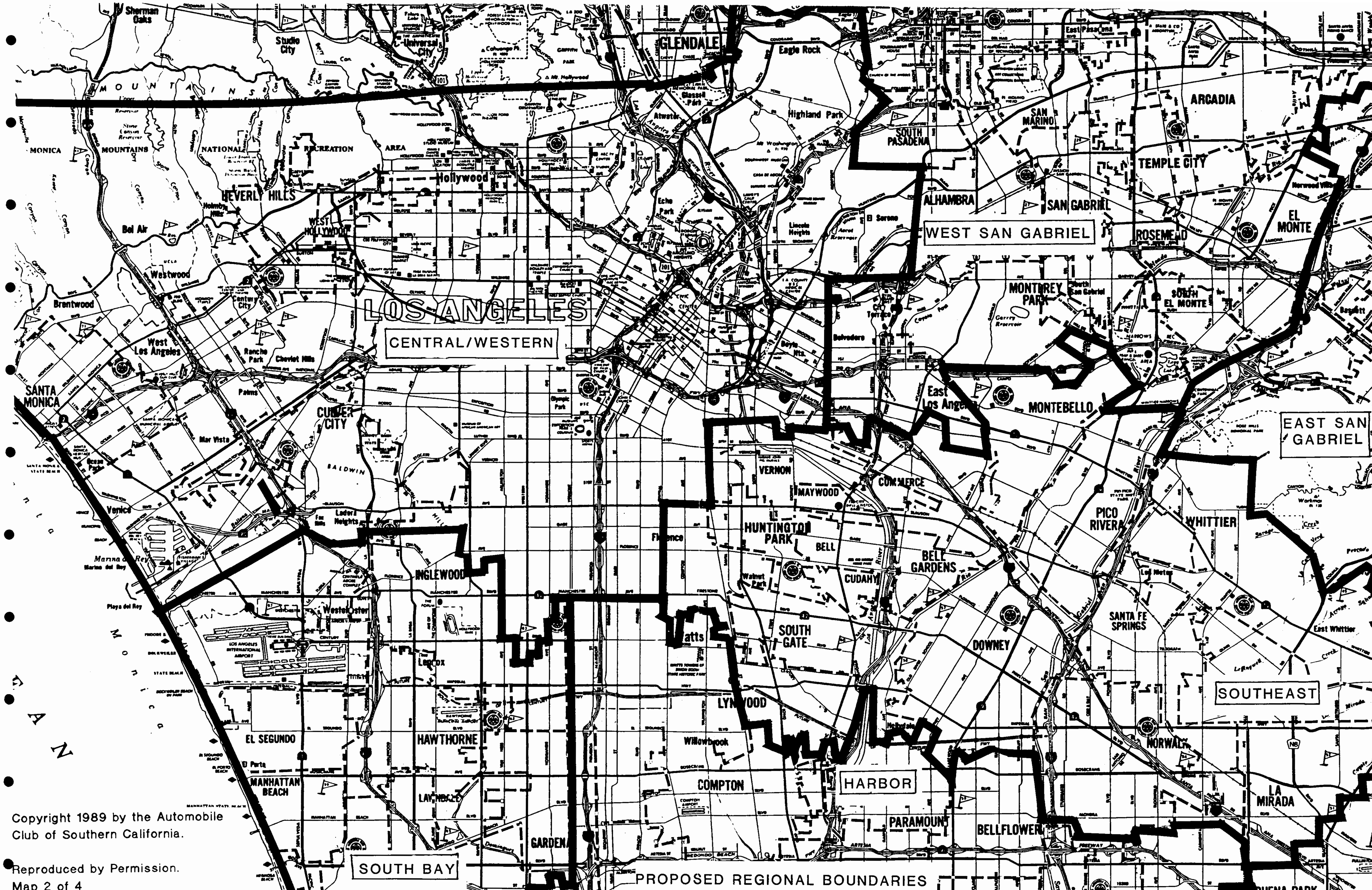
Map 1 of 4

PROPOSED REGIONAL BOUNDARIES



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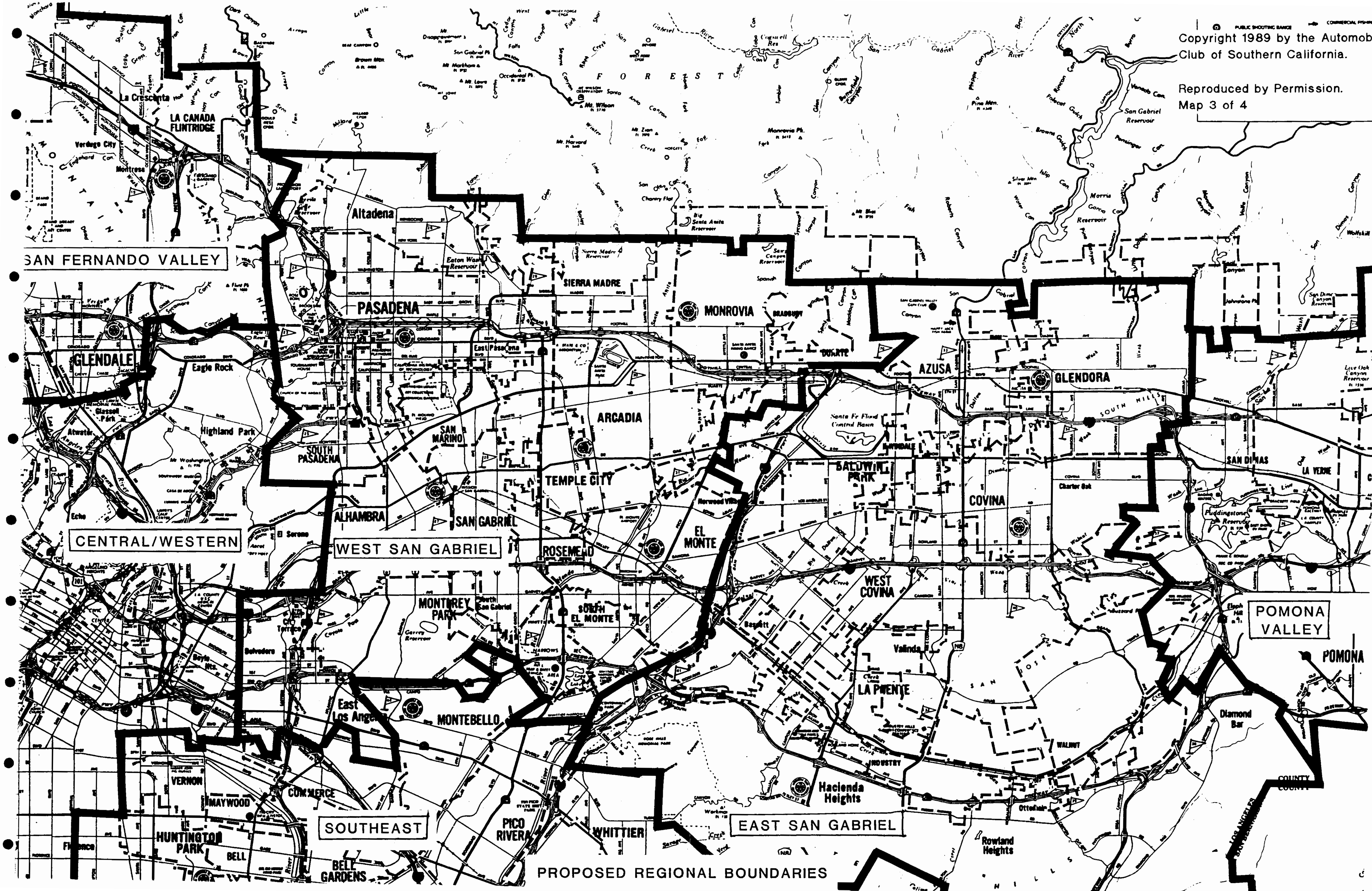
Map 2 of 4

PROPOSED REGIONAL BOUNDARIES



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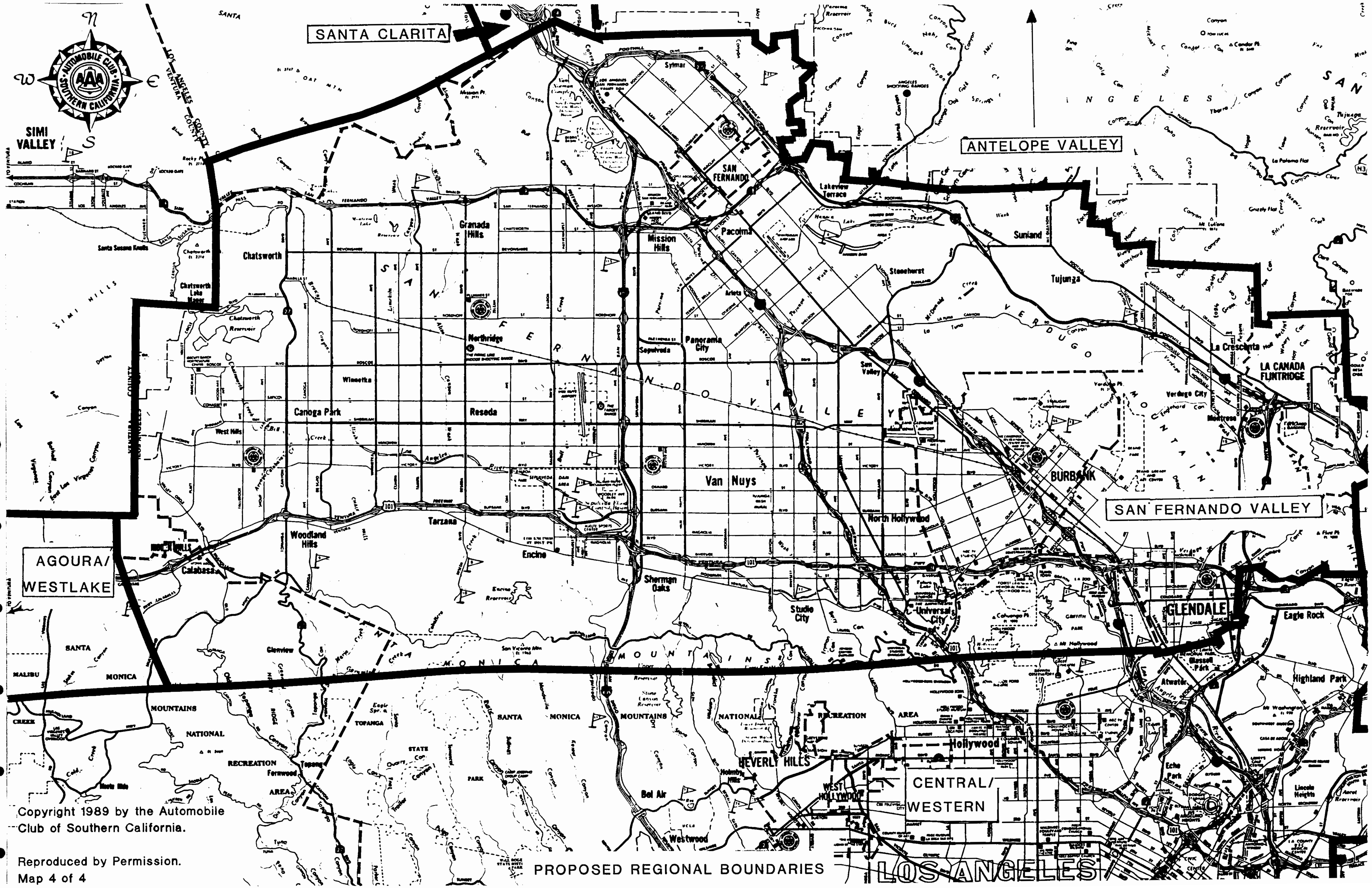
Map 3 of 4
SAN FERNANDO VALLEY
CENTRAL/WESTERN
WEST SAN GABRIEL
SOUTHEAST
EAST SAN GABRIEL
POMONA VALLEY
LA CANADA FLINTRIDGE
La Crescenta
Verdugo City
Montrose
GLENDALE
Eagle Rock
Highland Park
Atwater
Glassell Park
Echo
Altadena
PASADENA
SOUTH PASADENA
SAN MARINO
ALHAMBRA
SAN GABRIEL
El Sereno
SIERRA MADRE
MONROVIA
ARCADIA
TEMPLE CITY
ROSEMEAD
EL MONTE
East Pasadena
DUARTE
AZUSA
GLENDORA
BALDWIN PARK
COVINA
WEST COVINA
SAN DIMAS
LA VERNE
Charter Oak
MONTEREY PARK
South San Gabriel
SOUTH EL MONTE
Belvedere
East Los Angeles
MONTEBELLO
Valinda
LA PUENTE
Hacienda Heights
Rowland Heights
Diamond Bar
POMONA
WALNUT
INDUSTRY
PICO RIVERA
WHITTIER
COMMERCE
VERNON
MAYWOOD
HUNTINGTON PARK
BELL
BELL GARDENS
Florence
FOREST
Mt. Wilson
PROPOSED REGIONAL BOUNDARIES



Map 4 of 4

PROPOSED REGIONAL BOUNDARIES

APPENDIX D

GLOSSARY OF TERMS

GLOSSARY OF TERMS

Analog - Information represented by continuous and smoothly varying signal amplitude or frequency over a certain range; such as in human speech or music.

Antenna - A device for radiating and receiving electromagnetic waves.

Arterial Master - An item of equipment which is located on-street and which coordinates the operation of intersection controllers. Signal timing plans and plan selection schedules are executed by the arterial master. The communication network between the arterial master and the intersection is comprised of dedicated lines.

Asynchronous - A mode of transmission in which the time between sequential events (e.g., messages) is unpredictable.

Bandwidth - The range of signal frequencies that a medium or network will respond to, or carry without excessive attenuation.

Baud - A unit for expressing the rate at which information is transmitted.

Baud Rate - The transmission speed of a data channel.

Bit - An abbreviation of Binary digit; a single character in a binary number.

Broadband Communications - Transmission of signals with a large bandwidth, a term that is in some ways deliberately vague. Often used to denote video transmission.

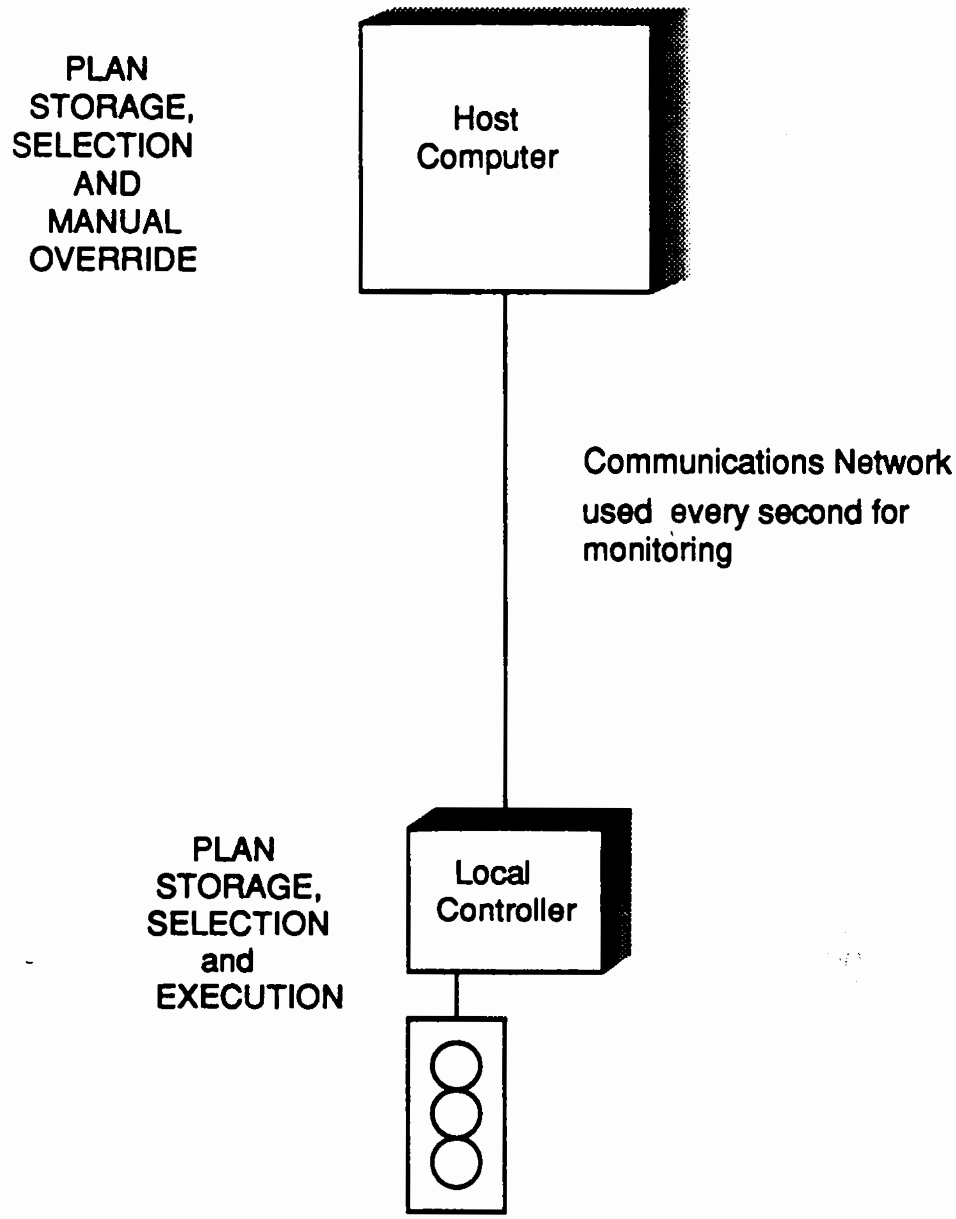
bps - Bits per second. The measure of transmission speed in serial systems.

Byte - A group (word) of 8 bits operated on as a unit.

Carrier - A single frequency which is modulated to communicate information.

Centralized Distributed System - A control system in which a computer and its associated peripherals are located centrally and which communicates regularly (typically every second) with intersection controllers for monitoring purposes. Signal timing plans and plan selection schedules are downloaded to intersection controllers where they are executed. Intersection controller parameters can also be downloaded. This communications network between the central and the intersection controllers is comprised of dedicated lines.

CENTRALIZED DISTRIBUTED SYSTEM



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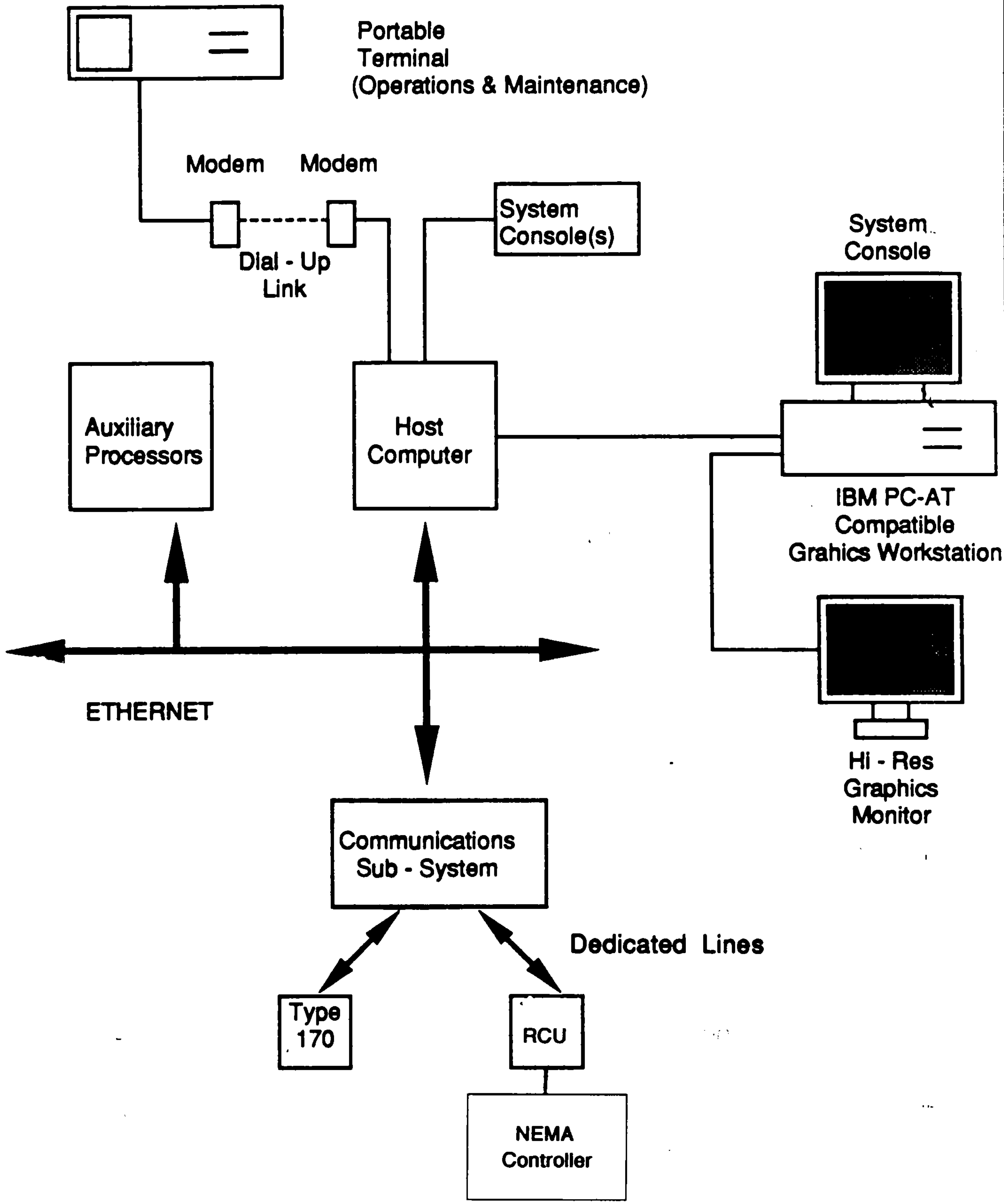

CENTRALIZED DISTRIBUTED SYSTEM

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Centralized System - A control system in which a computer and its associated peripherals are located centrally and which regularly sends control commands to intersection controllers (typically every second). Traffic signal timing plans and plan selection schedules are executed by the central computer. The communications network between the central and the controllers is comprised of dedicated lines.

Channel - A path of communication between two points. Also used at times to refer to particular frequency range or type of transmission over a link, such as a television "channel".

Closed Loop System - A system in which a central computer communicates at irregular intervals with one or more arterial masters for monitoring purposes. Signal timing plans and plan selection schedules can be downloaded to the arterial master where they are executed. The communications network between the central and the arterial master can be dial-up or dedicated.

Communication Link - A medium for carrying information between two points. This may be analog (voice) or digital (data) and may be direct connect (e.g. cable) or otherwise (e.g. radio).

Cross Talk - Interference or presence of unwanted signals from one transmission channel, detected on another (usually parallel) channel.

Dedicated Line - A communication link which is permanently connected.

Demodulation - The process of extracting transmitted information from a carrier signal. The opposite of modulation.

Dial-Up Line - A communication link which forms part of the public switched telephone network.

Digital - Information in discrete or quantized form; not continuous.

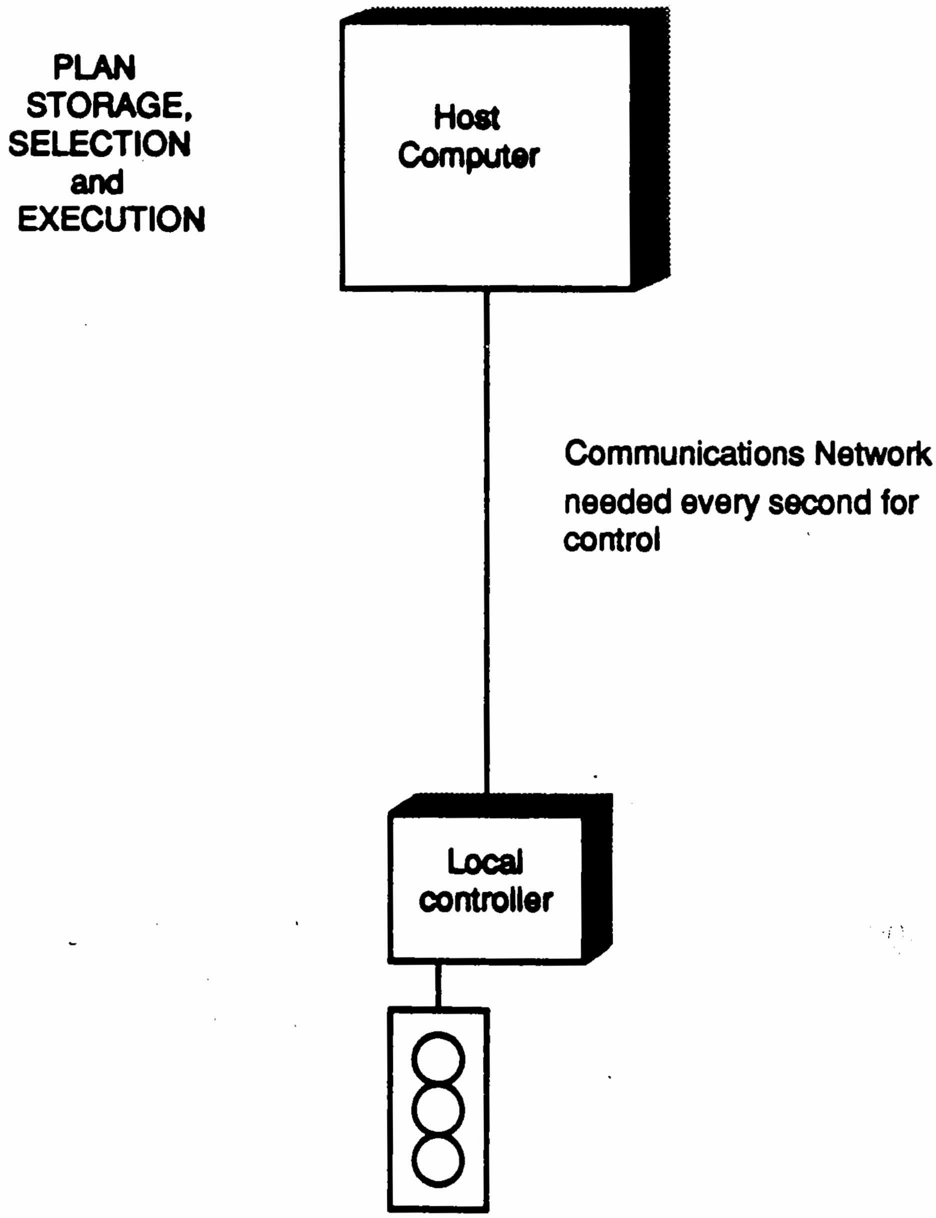
Download (Upload) - The transfer of blocks of data between a central and on-street equipment. The reverse is the uploading of data.

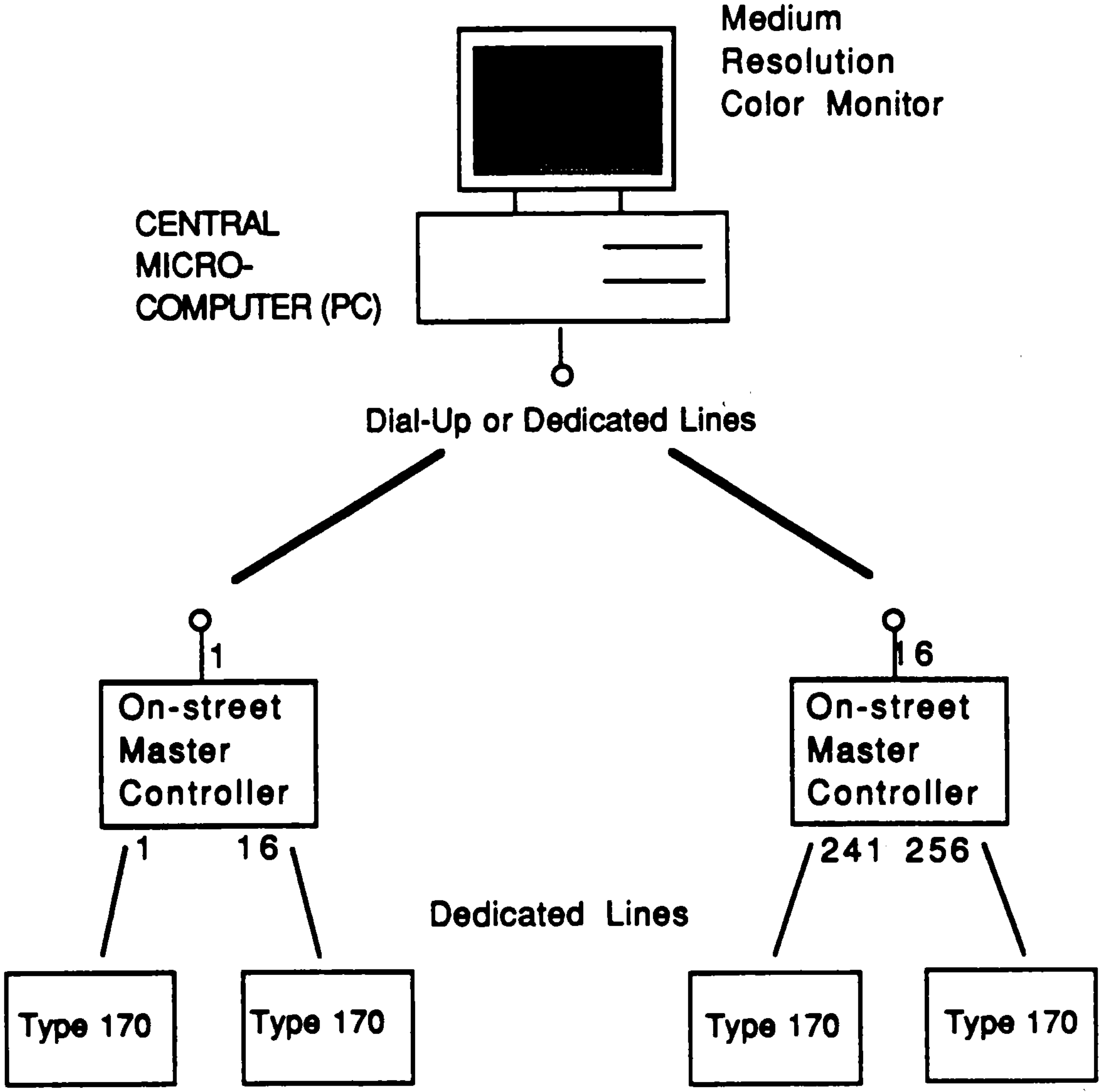
Drop - Receiver on a transmission line. A drop may also act as a transmitter in a two-way communication network.

FCC (Federal Communications Commission) - A government agency that regulates and monitors the domestic use of the electromagnetic spectrum of communications.

Frequency Division Multiplex (FDM) - A system of transmission in which the available frequency transmission range is divided into narrower bands, so that separate messages (channels) may be transmitted simultaneously on a single line.

TRADITIONAL CENTRALIZED SYSTEM





Closed Loop Master System

Type 170

jhk

Frequency Modulation (FM) - A method of data transmission whereby the frequency of a sinusoidal waveform (carrier) is changed in accordance with the information that is to be transmitted.

Frequency Response - The plot of frequency versus the ratio of output to input signal for a medium.

Full Duplex - A transmission link providing simultaneous transmission and reception in both directions.

Half Duplex - A transmission link providing both transmission and reception in both directions, but not simultaneously.

Hertz (Hz) - A measure of frequency, defined as one cycle per second.

Leased Line - A communication link which is leased from a telephone company and which does not form part of the public switched telephone network.

Medium - The composition of the path along which a communications signal is propagated, such as wire pair, coaxial cable, optical fiber or air-path.

Modem - A device used at both ends of a communication channel to transmit and receive data. Contraction of Modulator Demodulator.

Modulation - The process of controlling and modifying the properties of the carrier signal so that it contains the information to be transmitted. Often digital information is superimposed on a sinusoidal (analog) waveform.

Multipoint Connection - The connection of two or more drops to a single communications channel.

Multiplexing - A communications technique which allows more than one item of information to be transmitted or received over the same channel.

Noise - Any unwanted signal not present in the original transmitted information -- disturbances that tend to interfere with normal operations of the communication system.

Polling - A centrally controlled technique of sequentially calling a number of drops to permit them to sequentially transmit information back to central.

Repeater - A receiver and transmitter combination used to regenerate an attenuated signal.

Radio Frequency (RF) - As opposed to sound, light, infrared, or ultraviolet frequencies.

Serial Data - The transmission of digital data in a sequential pattern -- one bit at a time.

Simplex - A transmission link capable of transmission and reception in one direction only.

Telco - A generic term for a telephone company.

Time Division Multiplexing - A technique for transmitting several different messages over a single channel by dividing a fixed interval of time into several time slots into which a discrete message is sent in each time slot.

Transmission Link - The path over which information flows from sender to receiver.

Trunk - A transmission link joining two points. It is distinguished by its large information carrying capacity and by the fact that all signals go from point-to-point without branching off to any separate drops except at the end points.

Video Signal - The electrical signal containing the picture content information in a television system.

APPENDIX E

USE OF COMMON TIME REFERENCE

USE OF A COMMON TIME REFERENCE

Basic Concept

The basic concept for enabling inter-equipment coordination using a common-time reference is as follows:

- o All systems, masters and controllers would use a common highly accurate time reference to establish the time of day.
- o Each day, the "time zero" reference point for all cycle lengths for all control equipment would be made to occur at precisely the same time (called here, the base reference time).
- o The zero reference point for any cycle length used during the day would be established by having the master calculate back to the base reference time. This operation is the equivalent of having all cycle clocks running continuously since the base reference time. The continuous running of all cycle clocks is an alternative mode of operation which may be preferable for some masters.
- o Consequently, any two (or more) controllers in the County using the same cycle length would have their "time zero" reference points at exactly the same time (with certain types of equipment, the reference point for all cycles may be offset by a known constant which can, of course, be taken into account when calculating the offset values).
- o Each day, the "time zero" reference points would be resynchronized at the base reference time.

The Time Reference

The time reference which has been previously recommended by JHK for this purpose is WWV time broadcast via radio from Colorado and Hawaii. The broadcast time is the National Bureau of Standards (NBS) time derived from a cesium time reference. The WWV reference has been chosen over several other time references and is applicable for use in Los Angeles County for the following reasons:

- o WWV time is universally available throughout the County via special radio receivers. Receivers which would be used on central systems are commonly available as a part of the standard product lines of multiple manufacturers.

It is recognized that the County already has a program in place for the support of WWV installation at the intersection level. The equipment being supplied to the County is proprietary in nature which has caused funding problems.

However, the WWV signal can be received by a variety of radio receivers and there is no patent or restriction which is proprietary in nature on the building of equipment to receive and decode the signal.

- WWV provides long term accuracy with negligible drift.
- Power line frequency is maintained via WWV time. This element has a great benefit in the coordination of non-interconnected, time base coordinated signals. The importance of this relationship will be discussed in the section of non-interconnected signals.

The WWV (Colorado) radio signal is broadcast on 5 different frequencies and the WWVH (Hawaii) radio signal is broadcast on three different frequencies. WWV receivers scan all frequencies to find the strongest and then lock in on the signal.

Cycle Reference Calculation

As important as the WWV time reference is, if all systems and local time base coordinators established the time zero reference point of their cycle length clocks differently, coordination would not be achievable. Therefore, it is necessary for all control devices to use a common technique to establish the "time zero" reference point for each cycle length.

The technique for the cycle reference calculation which appears to be the best for this application is one which uses a fixed point in the day (the base reference time) at which time all cycle length clocks are assumed to be at time zero. Typically, this time would be between midnight and four in the morning. When a particular cycle length is scheduled to go into effect, its zero point is calculated as though its cycle clock had been running continuously from the base reference time. In this manner, all common cycle lengths on all masters in the County will be in synchronization without regard to whether or not they actually went into effect at the same time.

One minor drawback in this technique is that it requires the resynchronization of all cycle clocks once per day to a new "time zero" reference time. The resynchronizing of the cycle clocks will most likely require a resynchronization of traffic signals (as occurs at every change of timing plan during the day). However, if scheduled to occur at two or three o'clock in the morning, the procedure will produce only a minimal disruption to traffic flow.

The daily resynchronization to a new zero point could be avoided using a "fixed point-in-history" calculation. The zero point would be fixed instead of changing daily. This technique establishes the base reference time and data at some arbitrary point in history.

The cycle length zero reference time calculations are then referenced back to that particular date and time. Consequently, when clocks are resynchronized once per day to WWV and the cycle clock zero point calculations are made, the only time any traffic signals will need resynchronization is when there has been drift in the master's clock during the past 24 hours. This procedure however is much more complex to calculate and more difficult to implement than the previous technique.

Considering the minimal amount of disruption caused by the daily resynchronization technique and the fact that this technique (in one form or another) is currently in use by several suppliers, the daily resynchronization is deemed more desirable than the more complex fixed point-in-history procedure.

Coordination of Centralized Systems

Coordination between two centralized systems using the same cycle reference calculation algorithm can be achieved very simply by having both systems set their time of day clocks to WWV time periodically (nominally once per day). As many systems already make use of an external system clock, this should be a fairly simple modification or enhancement in most cases.

In the case of a centralized UTCS-type system (such as is currently being installed in Anaheim) where the central computer issues once-per-second cycle control commands, setting the central system time to WWV provides the necessary synchronization of cycles for all controllers in the system. Area wide system control greatly simplifies the ability to coordinate a large number of signals with WWV since the whole system only requires a single time reference unit installed at the central computer.

Other types of centralized systems utilize the local controller/coordination unit to perform cycle timing and control functions based on downloaded plan parameters. In these types of systems, coordination can be achieved by periodically downloading the time of day from the central computer. Again, this could be achieved by the addition of a single time reference (WWV receiver) at the central computer which the system would use to set is internal clock.

Modifications to local intersection equipment would be needed in the case of a UTCS-type system which uses a local time based coordinator for backup operation. The setting of the local time of the day could be accomplished by a time-of-day download, at any time or perhaps at a fixed point in the day, by a discrete output to the intersection communications unit.

Coordination of Distributed Systems

The class of traffic control systems known as distributed systems consists of those which divide the control functions among a master, submasters, and the local controller equipment. This type of system configuration is hierarchical in nature.

The technique used to coordinate a distributed system would depend on its specific configuration. In one type of distributed system, the local controllers are interconnected to an on-street master which reports to a central master via a dial-up circuit or other communications link. Another common configuration is to have the local controllers interconnected to an on-street master without a central master.

In the first configuration, with the presence of a central master, the coordination could be achieved much as described for the centralized system with local cycle control and timing functions. A single time reference could be installed at the central master to serve the entire system. The central master would periodically set the correct time of day at the on-street masters, and the on-street masters would in turn relay the correct time of day to the local controllers.

As these types of distributed systems usually have the capability of setting the local controller time from the central master, the addition of the capability to synchronize with WWV and resynchronize cycle clocks daily should be a fairly minor modification. As with the central system, the local controller/coordinator units would be required to use the "base reference time" cycle calculation technique. As discussed previously, this technique is not overly complex and could easily be added to new systems if it does not already exist in the current product line.

In the second distributed system configuration without a central master, the concept is very similar to the one described above with the exception that the on-street masters must be regularly synchronized with WWV broadcast time. This can be accomplished in a number of ways.

One technique would be to provide a WWV receiver at each on-street master location. This is a feasible approach since the low cost of the receiver units and antennas would not make it impractical. An appropriate interface to the master unit, such as an additional serial port, would need to be developed as well as the necessary software to read the clock receiver. At least one controller manufacturer provides this capability at present.

If however, this technique is impractical for retrofitting to existing equipment because of interfacing requirements or other considerations, it would be possible to accomplish coordination via a more manual procedure. The procedure is essentially the same as that for non-interconnected local controllers. It will be discussed briefly below and in detail in the following section.

Basically, because the power company maintains line frequency accuracy via WWV time, it is possible for a controller or master which derives its time of day from the power line frequency to achieve long term accuracy in its time keeping without additional outside correction. By devising a manual procedure to accurately set the clocks in the on-street masters, effective coordination between the masters and other systems can be achieved and maintained over relatively long periods of time. Only in the event of a power failure or some other power disturbance might the clocks have to be checked and reset.

Coordination of Non-Interconnected Local Controllers

As with the on-street masters, one technique to synchronize non-interconnected local controllers and coordination units to WWV time is to install a WWV receiver and antenna at every controller. At least one product of this type is currently on the market, and a project is underway in Los Angeles County to install these receivers on numerous County roadways. However, unlike the situation with the on-street master, it may be less likely to be a cost-effective retrofit for existing controllers.

Unlike the central computer type system, coordination systems which use local coordination units (time based coordinators) such as in Los Angeles County also require a software modification to accommodate the universal cycle reference calculation algorithm. In addition to adding a WWV at each location, a software modification to enable each controller to be synchronized with WWV is required if the units do not already use the "base reference time" technique described previously.

An alternative solution, as briefly described in the previous section, is to have the controller track WWV time via the power line frequency. Because of the long term accuracy afforded by the power line frequency, many controller and coordinator suppliers already use this technique to maintain time.

A procedure to initially set or reset the local clocks could be implemented in the jurisdictions in the County which do not have interconnected systems as follows:

- o Each jurisdiction would procure a WWV receiver to be permanently located at some central location, perhaps at the signal shop.
- o A simple software procedure would be developed to allow a portable laptop computer to query the WWV receiver and set its internal clock to WWV time.
- o Just prior to a new installation, or a maintenance visit to a non-interconnected controller, a technician would have the portable set is time from the WWV receiver.
- o Upon arrival at the new installation, the technician, using another software procedure, would have the portable download the correct time into the local controller or coordinator.
- o The controller or coordinator would then use the power line frequency to maintain the correct time until the next scheduled visit.

This is only one suggested procedure. There are several variations of this technique which could be used to provide WWV time to local control devices with varying degrees of complexity and accuracy.

It is unreasonable to assume that the controller or coordinator could maintain accurate time indefinitely. Therefore, controller clocks should be reset periodically to provide effective coordination. How often the clocks would need to be reset is a function of several variables as follows:

- o Power line frequency drift - This parameter is constantly monitored and continuously corrected for in the power grid. This parameter is limited by the power company to a maximum of plus or minus two seconds of WWV at any given time. This limit is exceeded on the order of twice per year for very short periods and is corrected by the utility.
- o Power outages - On loss of power, line frequency is not available for a time reference. Interim time can be maintained via a battery powered crystal reference with very good short term accuracy.
- o Controller Derivation of Line Frequency - Even though this process is performed by a fairly simple hardware arrangement, some controllers and coordinators do not maintain accurate time over the long term using power line frequency due to susceptibility to line noise and other problems.

Given these variables, a reasonable estimate of the average period over which a controller or coordinator could maintain time with enough accuracy for effective coordination is approximately six months. There will be some variability in this period based on the above factors. The LA County signal shop, for example, recommends checking any controller clock which is depended upon for coordination at least every <u>three</u> months.

APPENDIX F

LIST OF GOALS AND FUNCTIONS

List of Goals and Functions

Goal	Function
Traffic Control	Traffic Responsive Operation TOD/DOW Scheduler Critical Intersection Control Special Function Capability Compatibility with Existing Controllers Coordination Between Signal Groups Permissive Period Compatibility with Local Preemption
System Control and Management	On-Line Timing/Data Base Changes Ease-of-Use/Operations Data Base Unattended Operations Change Controller Settings from Central Monitor Equipment Operation/Malfunctions Remote Terminal Operator Interface Methods/Language Color Graphics Display
Reliability and Maintenance	Standby System Capability Proven Technology Communications Reliability Required Maintenance Technology Outside Maintenance Assistance Interchangeability
Operations and Engineering Analysis	Permanent Count Stations Measures of Effectiveness Interface to Offline Analysis System Event Log Report Configuration
Implementation	Existing System Impact Construction Time System Expansion System Capacity Group Assignament Flexible/Technical Advances