TRAFFIC SIGNAL PRIORITIZATION METHODOLOGY STUDY

HONOLULU, OAHU, HAWAII

FINAL

August 12, 2015

Prepared for:

City & County of Honolulu
Department of Transportation Services
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AUSTIN, TSUTSUMI & ASSOCIATES, INC. CIVIL ENGINEERS • SURVEYORS
CONTINUING THE ENGINEERING PRACTICE FOUNDED BY H. A. R. AUSTIN IN 1934

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FINAL

TRAFFIC SIGNAL PRIORITIZATION METHODOLOGY STUDY

Honolulu, Oahu, Hawaii

1. EXECUTIVE SUMMARY

The purpose of this study is to provide a methodology to prioritize the installation and modification of traffic signals for the City and County of Honolulu. After conducting thorough research which resulted in no national or state-wide standard found for traffic signal prioritization, it was determined that the Traffic Signal Prioritization Procedure used by the City of Rancho Palos Verdes Public Works was the most appropriate existing traffic signal prioritization method currently in use. The Traffic Signal Prioritization point system used in the excel program is adapted from the Traffic Signal Prioritization Procedure based on preferences from the City and County of Honolulu Department of Transportation Services and is outlined in Table 1 of the report. The created program uses the point system to determine the order in which City and County of Honolulu traffic signal implementation or modification projects should be addressed. This report outlines the process of developing the prioritization methodology. Hereinafter, “Project” shall refer to the Traffic Signal Prioritization Methodology Study.

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2. PURPOSE

The purpose of this report is to document the findings of the Traffic Signal Prioritization Methodology study conducted by Austin, Tsutsumi and Associates, Inc. (ATA). The Project aims to document a method which can be used to prioritize the installation and/or modification of traffic signals for the City and County of Honolulu.

The report is not intended to replace or override the guidance, requirements, and/or methodologies prescribed by current reference manuals and/or guidelines. The Project has been adapted from other publications and should not be used as the sole means of warranting implementation or modification of a traffic signal. Engineering judgment should be used to determine whether a traffic signal should be implemented or modified.

3. LITERATURE REVIEW

To date, there is no current methodology for the prioritization of traffic signal installation or modification for the City and County of Honolulu or any State of Hawaii jurisdiction. To fulfill the scope of work, Federal, State and jurisdictional literature have been reviewed for existing traffic signal prioritization methodology. No national or state-wide standard for traffic signal prioritization was found. However, the City of Rancho Palos Verdes Public Works developed its own standard for traffic signal installation prioritization in the Traffic Signal Priority Procedure. All research conducted is presented below.

3.1 Published Work

The following pieces of published work were reviewed and were considered for use as a basis for guidelines. The pieces of work are listed in descending order of jurisdictional literature.

3.1.1 Highway Safety Manual (HSM)

The Highway Safety Manual (HSM), published in 2010 by the American Association of State Highway and Transportation Officials' (AASHTO), is a general guide for decision making based on safety performance. The HSM provides a method to prioritize the implementation of projects, however, is not necessarily specific to traffic signals. Three prioritization methods are described: Ranking by Economic Effectiveness Measures, Incremental Benefit-Cost Analysis, and Optimization Methods.

Ranking by Economic Effectiveness Measures provides a prioritized list based on a chosen criterion. The process involves ranking projects or project alternatives by an assortment of measures, including project costs, number of crashes reduced, cost-effectiveness, net present value, etc. The project list is ranked high to low on any one measure. Because this method is very simplistic and does not account for multiple competing priorities, budget constraints, or other project impacts, it was not considered as a comprehensive means for prioritizing traffic signal systems.

Incremental Benefit-Cost Analysis also provides a prioritized list of projects based on a chosen criterion. This method differs from Ranking by Economic Effectiveness Measures in that it is based on a benefit-cost ratio analysis. The benefit-cost ratio analysis methodology assigns monetary value for societal crash costs such as fatalities and injuries to determine the benefit-cost ratio. Not only is this procedure arbitrary and vague in assignment, but the method only considers the reduction in crashes as the sole objective of prioritization. For these reasons, the benefit-cost analysis method was not considered a comprehensive means for prioritizing traffic signal systems.

The Optimization Methods use linear programming, integer programming, and/or dynamic programming to provide project prioritization consistent with incremental benefit-cost analysis and considers the impact of budget constraints in creating an optimized project set. Generally, computer software packages are used to efficiently solve prioritization by optimization problems. However, similar to the incremental benefit-cost analysis, the optimization methods only consider the reduction in crashes as the sole objective of prioritization. For this reason, the prioritization by optimization methods were not considered a comprehensive means for prioritizing traffic signal systems.

The HSM describes another Optimization Method, the Multi-Objective Resource Allocation method, which uses decision-making algorithms to quantify and address multiple objectives aside from only crash reduction. In Multi-Objective Resource Allocation, the user assigns weights to each of the multiple objectives under consideration for project prioritization, and then uses the weights to balance and evaluate the objectives in decision-making. As the underlying methodology of incorporating multiple objects in project prioritization was an important and desired trait for this Project, the Multi-Objective Resource Allocation basic methodology was used in the development of this Project.

Although the FHWA acknowledges the existence of the HSM, no transportation agencies or entities contacted for this study use the HSM as a guideline for traffic signal prioritization.

3.1.2 Minnesota Department of Transportation

The Minnesota Department of Transportation uses a ranking system to prioritize projects in their Highway Safety Improvement Program (HSIP), which is a program that identifies, implements, and evaluates cost effective construction safety projects. Projects are generally prioritized based on crash history, project cost and engineering judgment.

However, because this method is not specifically defined, does not account for multiple competing priorities, and is only intended to evaluate construction safety projects in general, it was not considered as a comprehensive means for prioritizing traffic signal systems and was not used in the development of the Project.

3.1.3 City of Rancho Palos Verdes Public Works

On June 27, 2005, the City of Rancho Palos Verdes Traffic Safety Commission approved the citywide Traffic Signal Priority Procedure. The procedure prioritizes a list of uncontrolled intersections in need of new traffic signal installation. Priority for modifications to existing traffic control signals are not included in this procedure and are assessed on a case-by-case basis.

The procedure is carried out in three phrases. In Phase I, intersection data is collected for analysis. Phase II justifies the installation of traffic signals through traffic signal warrant analysis, using the data from Phase I. Once a location has been deemed justified and appropriate for the installation of a traffic signal, Phase III applies criteria to rank the priority of the location for installation.

The traffic signal prioritization guidelines provided by the Traffic Signal Priority Procedure, published by the City of Rancho Palos Verdes Traffic Safety Commission, are the most comprehensive and practical published methodology to date. The Traffic Signal Priority Procedure also was the only publication found to include weighted criteria in a point allocation format and provide guidelines to account for the widest range of decision factors. Due to these strengths, the procedure was used as a basis for the Project.

3.2 E-mail Correspondence

In an effort to obtain nationally recognized methodologies for traffic signal prioritization, five (5) employees from Caltrans, one (1) employee from the Federal Highway Administration (FHWA), and two (2) employees from the Manual of Uniform Traffic Control Devices (MUTCD) were contacted via e-mail for research.

A Caltrans Transportation Planner from the State Planning Branch directed ATA to contact California's Division of Traffic Operations. Caltrans' Office Chief from California's Division of Traffic Operations stated that the State of California uses the MUTCD Signal Warrant #7, which considers crash experience, and cost benefit analysis with collision and volume as the variables to determine traffic signal prioritization. The Office Chief also stated that safety projects in regards to traffic signal implementation are a top priority for the organization. All signal warrants were included as prioritization criteria for the Project.

A Safety Engineer from the FHWA was also contacted. The Safety Engineer noted the importance of establishing a traffic signal prioritization scheme and suggested that the Highway Safety Manual, which provides tools to predict the safety performance of intersections, be used together with operational analysis to identify the effect of traffic signal installation at given locations. While these items were considered in the development of this study, no new information was gleaned regarding FHWA guidelines for traffic signal prioritization.

Response from a MUTCD team member also did not yield in any new information regarding national guidelines for traffic signal prioritization.

3.3 Telephone Correspondence

Various agencies presumed to employ a procedure for traffic signal prioritization were contacted by telephone. The agencies contacted include the California Department of Transportation, Seattle Department of Transportation, Washington State Department of Transportation, New York City Department of Transportation, Los Angeles Department of Transportation, and the San Jose Department of Transportation. Some of the agencies contacted did not respond, while others stated their agency did not currently use any type of published prioritization system. The California Department of Transportation directed ATA to the Rancho Palos Verdes Public Works' Traffic Signal Priority Procedure, while all other agencies contacted had no published prioritization methodology.

3.4 Findings

After thorough research efforts, the City of Rancho Palos Verdes Public Works' Traffic Signal Priority Procedure was found to be the only comprehensive and applicable method for prioritizing traffic signal installation. The Project guidelines were adapted from this method to include additional criteria for consideration and to prioritize traffic signal modifications in addition to new installations.

Multi-Objective Resource Allocation methodology from AASHTO's Highway Safety Manual, the only nationally published record of project prioritization, serves as the underlying methodology for both the City of Rancho Palos Verdes Public Works' Traffic Signal Priority Procedure and correspondingly, the Project. The methodology, which involves assigning weights to multiple objectives under consideration for project prioritization, is both a comprehensive means for prioritizing projects and is a desired trait in the formulation of the Project guidelines. Beyond this methodology, the HSM was not otherwise considered in the formulation of the prioritization methodology, as it is not currently being used by any transportation entity contacted for this study to prioritize traffic signalization based on current knowledge.

The Minnesota DOT methodology was not considered, as it was not specific to traffic signal installation and did not account for a comprehensive list of prioritization criteria.

4. METHODOLOGY

After extensive review of information collected though the research process, it was determined that a point system would be most effective and understood in prioritizing signal installation and improvement projects. The proposed prioritization point system is based off the City of Rancho Palos Verdes Public Works, Traffic Signal Priority Procedure. Various adjustments were implemented to the system such that it could be applied to the island of Oahu and meet the standards of the Department of Transportation Services (DTS). Adjustments included modifying the point system such that the requests of DTS were met, while maintaining a similar ratio of points per category as the Rancho Palos Verdes procedure. This was done to keep the proposed point system as close to the Rancho Palos Verdes procedure as possible, since the Rancho Palos Verdes procedure has been approved for the city of Rancho Palos Verdes and is currently in use. Table 1 shows the breakdown of the Rancho Palos Verdes procedure compared to the proposed procedure by category.

Table 1: Point breakdown by category.

	Rancho Palos Verdes		**Proposed**		
Category	Points Assigned	% of Total Points	Points Assigned	% of Total Points	% of Total Points – Not including added categories***
Traffic Volume	20	14%	26	13%	15%
Pedestrian/Bike	30	21%	32	16%	18%
Speed	5	3.5%	5	2.5%	3%
Crash	84*	58%	107*	54%	61%
Special Conditions	5	3.5%	5	2.5%	3%
Other MUTCD Warrants***	---	---	8	4%	---
Time Spent on List***	---	---	**	--	---
Improvement Type***	---	---	15	8%	---
Total	144	---	198	--	175

* Assuming 1 crash, 1 injury, and 1 property damage crash – Note that this category has no cap; therefore there is no limit to the number of points awarded in this category.
** Assuming 0 years spent on the list – Note that 5 points is added to this category for each year the intersection spends on the list.
*** Extra categories include categories that are not considered in the Rancho Palos Verdes' Traffic Signal Priority Procedure (Other MUTCD Warrants, Time Spent on List, and Improvement Type)

To determine the allocation of points used in the proposed point system shown in the table above, the following logic was applied:

Crashes: In order to determine the number of points to allot for each type of crash (fatality, injury, and property damage), the ratio of points applied in the Rancho Palos Verdes procedure was used as a basis. The number of points for the proposed point system was increased such that the ratio of points for each type of crash in comparison to each other remained similar to the

Rancho Palos Verdes procedure. The weight of the crash category as a percent of the total points was also kept close to that of the Rancho Palos Verdes procedure.

Pedestrian/Bicycle: The pedestrian/bicycle point system was adopted from the Rancho Palos Verdes procedure.

Average Daily Traffic: The average daily traffic point system was adopted from the Rancho Palos Verdes procedure.

Peak Hour Traffic: The peak hour traffic point system was adopted from the Rancho Palos Verdes procedure.

Speed: The point system used to determine the amount of points allotted for each speed bracket was adopted from the Rancho Palos Verdes procedure.

Special Conditions: The special conditions category was adopted from the Rancho Palos Verdes procedure. The value of each activity center (see Attachment 1 for the list of activity centers being considered) remains the same, but rail station was added to the list of activity centers, to account for the Honolulu Rail Transit, which is currently under construction. Some items were eliminated from the safety concerns list because they are not applicable to Hawai‘i, and the number of points assigned for the remaining safety concern was increased to keep the weight of the special conditions category similar to that of the Rancho Palos Verdes procedure.

Traffic Signal Warrants: Per the request of DTS, MUTCD traffic signal warrants were considered as part of the point system. For each warrant satisfied, two (2) points are assigned. Although some of the warrants overlap other point assignment categories, the stipulations to satisfy warrants differ from those outlined in the point assignment categories. Therefore, the assignment of points in this category is solely for the purpose of considering the number of warrants met.

Time on List: Per the request of DTS, a category for the amount of time any single traffic signal project spends on the prioritization list was added to the point system methodology. According to DTS it is preferable to update or install a signal within five (5) years of the signal installation/update approval. Therefore, five (5) points are to be assigned to every traffic signal for each year it spends on the prioritization list. It should also be noted that after a traffic signal project’s fourth year on the list, 100 points will be added, moving it towards the top of the list.

Improvement Type: Per the request of DTS, a category to assign points according to improvement type was included. The points assigned in this category are based on the idea that a new traffic signal has a higher priority than a signal modification, and if a left-turn signal is warranted it increases the priority of both improvement types.

The proposed procedure and point system for the Traffic Signalization Prioritization Methodology Study is shown in Attachment 1.

5. ATTACHMENTS

Attachment 1 – Procedure and Point System
Attachment 2 – References
Attachment 3 – Appendices

ATTACHMENT 1 – PROCEDURE AND POINT SYSTEM

Disclaimer: These guidelines have been adapted from other publications and should not be used as the sole means of traffic signal prioritization. Engineering judgment should always be used to determine which traffic signal installations and improvements are implemented.

The following data should be collected for the intersection considered:

1. *Crash History* – Collect crash history for the past three years.
2. *Traffic Volumes* – Collect traffic volume counts for each of the following:
    i. Each approach direction (hourly)*
    ii. Combined minor street (hourly)*
    iii. Combined major street (hourly)*
    iv. Total volume for the intersection*
    v. AM and PM peak hour volumes for each movement during a normal week day

    *Tube count data should be collected over a period of 2-7 days.
3. *Pedestrian* – Collect the volume of pedestrians crossing the highest volume street during the highest four hours of traffic volumes.
4. *Bicycle* – Determine whether the studied intersection is included in the O‘ahu Bike Plan.
5. *Existing Conditions* – Record the existing control measures (all way stop, signalized, etc.), posted speed limit in the area, roadway geometry, and nearby developments that could affect traffic (see the special conditions point assignment category to determine which developments are significant and should be noted).
6. MUTCD Traffic Warrants – Determine satisfied MUTCD traffic warrants.
7. Time Spent on List – Determine the number of years each intersection has spent on the traffic signal prioritization list.

8. Improvement Type – Determine what type of improvement is required (new signal or modification). Also, determine whether a left-turn signal is warranted at the studied intersection.

Once data is collected for each intersection being considered for signalization, the point system which was adopted from the City of Rancho Palos Verdes Citywide Traffic Signal Installation Procedure, as shown on the following pages should be applied to each intersection. After the proposed point system has been applied, the intersections being considered for signalization/modification should be prioritized in order from most to least number of points.

To assure that all data is up to date, accident data should be recollected each year, while all other data should be recollected every three years. However, if major changes impacting traffic patterns occur near any of the studied areas, traffic counts should be updated as soon as possible. All updated information should be applied soon after it is collected, and the traffic signal prioritization list should be reassessed.

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Crashes

MAXIMUM NUMBER OF POINTS: NONE

Points should be assigned for the past three years of crash history, and then the total number of points should be divided by three to get the yearly average of points. Crash type is based on the worst type that occurred during the crash.

Crash Type	Points per Occurrence
Fatality	60
Injury	30
Property Damage	15

Pedestrians/Bicycles

MAXIMUM NUMBER OF POINTS: 30

Pedestrians (General)

MAXIMUM NUMBER OF POINTS: 10

Points should be assigned based on the number of pedestrians crossing the street with a higher volume of traffic during the highest four hours of traffic.

Number of Pedestrians	Points
0-9	0
10-19	1
20-29	2
30-39	3
40-49	4
50-59	5
60-69	6
70-79	7
80-89	8
90-99	9
100+	10

Pedestrians/Bicycles Continued

Pedestrians (School)

MAXIMUM NUMBER OF POINTS: 10

If there is a school within 600 feet of the nearest traffic signal on the major street, 10 points are assigned. If not, 0 points are assigned.

Bicycles

MAXIMUM NUMBER OF POINTS: 10

If the traffic signal project is identified on the O'ahu Bike Plan to house a bike lane, path, or route in the present or future, assign 10 points to the intersection. If the location is not identified by the O'ahu Bike Plane to include any bicycle facilities, assign 0 points to the intersection.

Average Daily Traffic (ADT)

MAXIMUM NUMBER OF POINTS: 10

	Side Street ADT					
Main Street ADT	<2,001	2,001-5,000	5,001-10,000	10,001-15,000	15,001-20,000	20,000+
<2,001	0	1	2	3	4	5
2,001-5,000	1	2	3	4	5	6
5,001-10,000	2	3	4	5	6	7
10,001-15,000	3	4	5	6	7	8
15,001-20,000	4	5	6	7	8	9
20,000+	5	6	7	8	9	10

Peak Hour Traffic Volumes →

MAXIMUM NUMBER OF POINTS: 10

Street peak hour volumes are based on the highest directional traffic volume.

	Side Street Peak Hour Volume				
Main Street Peak Hour Volume	≤100	101-200	201-300	301-400	>400
≤400	0	0	1	2	3
401-600	0	1	2	3	4
601-800	1	2	3	4	5
801-1,000	2	3	4	5	6
1,001-1,200	3	4	5	6	7
1,201-1,400	4	5	6	7	8
1,401-1,600	5	6	7	8	9
>1,601	6	7	8	9	10

Speed →

MAXIMUM NUMBER OF POINTS: 5

Speed is based on the highest posted speed limit.

Posted Speed Limit	Points
50+	5
40-49	4
35-39	3
30-34	2
25-29	1
<25	0

Special Conditions

MAXIMUM NUMBER OF POINTS: 5

Activity Centers

MAXIMUM NUMBER OF POINTS: 3

Assign one point for each of the following that are within 1,000 feet of the location in question.

- Park
- Library
- Employment Center
- Event Center
- Sporting Center
- Sporting Facility
- Senior Center
- Commercial Center
- Fire Station
- Medical Facility
- High Density Residential
- Rail Station

Other Safety Concerns

MAXIMUM NUMBER OF POINTS: 2

Assign one point for each of the following that pertain to the location in question.

- Restricted Sight Distance

MUTCD Traffic Signal Warrants

MAXIMUM NUMBER OF POINTS: 18

Assign 2 points for each MUTCD Traffic Warrant that is satisfied.

- Warrant 1 – Eight-Hour Vehicular Volume
- Warrant 2 – Four-Hour Vehicular Volume
- Warrant 3 – Peak Hour
- Warrant 4 – Pedestrian Volume
- Warrant 5 – School Crossing
- Warrant 6 – Coordinated Signal System
- Warrant 7 – Crash Experience
- Warrant 8 – Roadway Network
- Warrant 9 – Intersection Near a Grade Crossing

Time Spend on the Prioritization List

NO MAXIMUM NUMBER OF POINTS

Assign 5 points for each year that the intersection has spent on the prioritization list.

After a traffic signal project's 4th year on the list, 100 points will be added, moving it towards the top of the list.

Improvement Type

MAXIMUM NUMBER OF POINTS: 15

Points should be assigned based on the type of improvements needed for the traffic signal project.

Improvement Type	Points
New Signal	10
Signal Modification	5
Left-Turn Signal Warranted	5

ATTACHMENT 2 – REFERENCES

1. City of Rancho Palos Verdes Public Works, Traffic Signal Priority Procedure, 2006.
2. Department of Transportation Services City and County of Honolulu, O‘ahu Bike Plan, 2012.
3. Minnesota Department of Transportation Metro District Traffic Engineering, Highway Safety Improvement Program, January 2009.
4. U.S. Department of Transportation Federal Highway Administration, Manual on Uniform Traffic Control Devices, 2009.

Attachment 3 – APPENDICES

APPENDIX A

Rancho Palos Verdes Citywide Traffic Signal Installation Procedure

RANCHO PALOS VERDES

MEMORANDUM

TO: TRAFFIC SAFETY COMMISSION

FROM: DIRECTOR OF PUBLIC WORKS

BY: JACK RYDELL, P.E., T.E., PTOE
CONSULTANT TRAFFIC ENGINEER

DATE: JUNE 27, 2005

SUBJECT: CITYWIDE TRAFFIC SIGNAL INSTALLATION PROCEDURE

RECOMMENDATIONS:

1. Establish the Traffic Signal Installation Procedure as outlined in Attachment A.
2. Request Staff return to the Traffic Safety Commission within 60 days with a Traffic Signal Prioritization List based on the procedure identified in Attachment A.

BACKGROUND

Traffic signals determine who has the right-of-way at an intersection or crossing. They facilitate orderly traffic flow, allow pedestrians to cross, and provide cross-street traffic with opportunity to cross or enter an intersection. When installed at appropriate locations, traffic signals can increase the capacity of an intersection, reduce the frequency of collisions and provide better minor street access. Because traffic signals are expensive to install (approximately $150,000 per location) and may induce safety, operational and progression problems if not properly placed, they should only be installed where they will clearly increase safety and make the intersection operate more efficiently.

Public Works Staff reviews requests to install new traffic signals on a regular basis. Locations for evaluation are generated through resident and Councilmember requests, Staff observations, collision analysis, development projects, etc. Staff then evaluates these locations using accepted Federal and State traffic engineering guidelines in order to identify those locations where new traffic signals are justified and appropriate. No further action related to signalization is required for locations that do not justify new signals. However other actions may be taken as determined by staff in order to improve traffic safety and flow. Staff reports for locations where new signals are not justified are generally not submitted to the Traffic Safety Commission, since no action by your Commission is required.

For locations where new signals are justified, action by the Traffic Safety Commission and City Council is required. At present there is no consistent program to prioritize these locations and to program the expenditure of funds. In several instances new traffic signals have been installed without consideration or comparison for more justified needs at other locations. In most cases the funding has had to be approved by City Council on an

individual basis outside of the normal budget process. To a lesser degree (do the generally lower cost), this also applies to modifications to existing traffic signals.

Beginning in 2002 as a result of a traffic study presented to the Traffic Committee to modify the traffic signal at Hawthorne Boulevard and Highridge Road/Grayslake Road, Staff and the Traffic Committee (now Traffic Safety Commission) have been tasked to prepare a Traffic Signal Prioritization List. This instruction came from City Council and is based on a combination of budgetary constraints and concern for traffic signal needs throughout the City. In addition to considering potential new signal installations, modifications to existing signals are to be addressed.

This item has been reviewed several times during the past few years, with no consensus being reached on a method to prioritize locations for new traffic signal installations. Due to the significant costs of designing and installing traffic signals, an objective means to determine the relative merits of various locations is desirable. Previous methodology considered included the following:

- Subjective rankings of the relative importance of current traffic signal warrants by Staff and the Traffic Committee;
- Consideration of additional factors, such as adjacent land use, posted speed limit and sight distance evaluation.

DISCUSSION

The recommended Traffic Signal Installation Procedure for new signal installations involves three phases. The initial screening process to determine if signalization is justified is determined during Phases I (data collection) and II (analysis). For locations where this process has determined that installation of a new traffic signal is justified and appropriate, Phase III applies criteria to rank the eligible locations. The Traffic Signal Installation Procedure is outlined in Attachment A. For your information and review, the Caltrans Traffic Signal warrant sheets are provided in Attachment B.

ALTERNATIVES

1. Do not recommend approval at this time and request additional information and additional analysis.
2. Make changes to the procedure.
3. Other alternatives to be determined.

Recommended for Approval

Ron Dragoo
Senior Engineer

Respectfully Submitted,

Dean E. Allison
Director of Public Works

JR: Citywide Traffic Signal Installation Procedure TSC Report - 6-27-05

Attachments: Attachment A - Traffic Signal Installation Procedure
Attachment B - Caltrans Traffic Signal Warrants Worksheets

TRAFFIC SIGNAL PRIORITY PROCEDURE

Phase I

In Phase I, the following data are collected for any location that has been suggested as a candidate for a traffic signal:

Collisions:	A recent three-year compilation of reported collision history differentiating types and correctability is developed.
Traffic Volumes:	24-hour volume counts with an hourly listing of each approach direction are obtained for the combined minor street volumes, the combined major street volumes and a total for the entire intersection. Peak hour (am and pm) traffic volumes by manual count for the turning and through movements are typically obtained.
Pedestrian/Bicycle:	As part of the peak hour vehicular movement counts, pedestrian and bicycle data are collected. If the pedestrian and bicycle peak periods differs from the vehicular peak periods, a separate manual count may be taken.
Existing Conditions:	The current type of control (two-way stop, all-way stop, etc.) is recorded, along with the posted speed limit, roadway geometry and adjacent developments affecting traffic patterns.

The above data is collected to screen eligible projects, as well as for use in placing justified locations within the prioritization list.

Phase II

In Phase II, the information from Phase I is combined with further study to determine which locations justify the installation of a traffic signal. An evaluation of traffic conditions utilizing the Caltrans Traffic Signal Warrants provide the first step in evaluating locations for potential signalization. The eight Caltrans traffic signal warrants, as found in the Manual of Uniform Traffic Control Devices (MUTCD) and the MUTCD 2003 California Supplement are complex, with minimum thresholds varying depending upon roadway geometry, approach speeds, type of development, proximity of other traffic controls, etc. The current traffic signal warrant worksheets are attached for reference purposes. A brief description of each warrant is as follows:

Warrant 1 – Eight-Hour Vehicular Volume

This warrant consists of two conditions. Condition A is intended for application at locations where a large volume of intersecting traffic is the principal reason to consider installing a traffic signal. Condition B is intended for application at locations where Condition A is not satisfied and where the traffic volumes on the major street is so heavy that the traffic on the minor intersecting street suffers excessive delay or conflict in entering or crossing the major street. This warrant can

also be satisfied if neither A nor B is satisfied, but both A and B are satisfied 80% and adequate trial of other alternatives that could cause less delay and inconvenience to traffic has failed to solve the traffic problems.

Warrant 2 – Four-Hour Vehicular Volume

This warrant is intended for application at locations where the volume of intersecting traffic is the principal reason to consider installing a traffic signal. Since only four hours are considered as opposed to Warrant 1, where eight hours are considered, the threshold volumes are significantly higher than for Warrant 1.

Warrant 3 – Peak Hour

This warrant is intended for use at locations where traffic conditions are such that for a minimum of one hour on an average day, the minor street traffic suffers undue delay when entering or crossing the major street. This warrant is only applied in unusual cases, such as office complexes, manufacturing plants, industrial complexes or high occupancy vehicle facilities that attract or discharge large numbers of vehicles over a short time.

Warrant 4 – Pedestrian Volume

This warrant is intended for application where there is significant pedestrian volume and traffic volume on the major street is so heavy that pedestrians experience excessive delay in crossing. For this warrant to be satisfied, the distance to the nearest traffic signal on the major street must be greater than 300 feet.

Warrant 5 – School Crossing

This warrant is intended for application where the fact that school children cross the major street is the principal reason to consider installing a traffic signal. For this warrant to be satisfied, the distance to the nearest traffic signal on the major street must be greater than 600 feet.

Warrant 6 – Coordinated Signal System

This warrant is intended to maintain proper platooning of vehicles in order to maintain or extend a coordinated signal system. This warrant is not applied when the resultant spacing of traffic signals would be less than 1,000 feet.

Warrant 7 – Crash Experience

This warrant is intended for locations where the severity and frequency of crashes are the principal reasons to consider installing a traffic signal. For this warrant to be satisfied, Condition A or B of Warrant 1 must be satisfied at least 80%, there must be a least five correctable accidents during a 12-month period and adequate trial of less restrictive remedies has failed to reduce accident frequency.

Warrant 8 – Roadway Network

This warrant is intended for locations where it is desirable to encourage concentration and organization of traffic flow on a roadway network. Besides requiring certain volume thresholds to be net, this warrant requires that the intersection consist of major routes.

As mentioned previously, these warrants are merely the minimum threshold levels, which if found to be met, shall result in the analysis of other traffic conditions and factors to determine whether a signal installation or other traffic operational change is justified. As such, the warrants are only part of the engineering study needed to justify the installation of a traffic signal and not the justification or a mandate in and of themselves for installation. In fact, the Caltrans Traffic Signal Warrant Worksheets specifically note the following:

> *The satisfaction of a warrant is not necessarily justification for a signal. Delay, congestion, confusion or other evidence of the need for right-of-way assignment must be shown.*

The Manual of Uniform Traffic Control Devices (MUTCD) also provides guidelines that require evaluation of other traffic conditions beyond just Traffic Signal Warrants:

> *A traffic control signal should not be installed if it will seriously disrupt progressive traffic flow.*
>
> *A traffic control signal should not be installed unless and engineering study indicates that installing a traffic control signal will improve the overall safety and/or operation of the intersection.*

This further study includes, but is not limited to, the following factors:

1. Analysis of the effect of signalization on existing traffic signal progression systems;
2. Review of adjacent traffic signal operational characteristics, such as phasing, timing and cycle lengths to determine compatibility and the potential for operational degradation at other signalized locations ;
3. Corridor traffic signal spacing with respect to safety and operational impacts;
4. Effects on motorist delay, air pollution, noise, fuel consumption, etc.

After this comprehensive engineering study is completed, Staff determines whether specific locations justify the installation of a new traffic signal.

Phase III

For locations where Phase II has determined that installation of a new traffic signal is justified and appropriate, the following criteria are applied to rank the eligible locations (there is no maximum score):

1. Collisions

(Max. Points: No Limit)

Points are assigned for each reported collision that occurred at the intersection during the previous three years that was susceptible to correction by signalization, as follows:

Type of Collision	Points per Occurrence
Fatal	48
Injury	24
Property Damage Only	12

The total points for the previous three years are divided by three to determine a yearly average that is then assigned to the proposed signal location.

2. Pedestrians/Bicycles

(Max. Points: 30)

A maximum of ten points are assigned for each of the following:

(A) Pedestrians (general)

Points are assigned based on the number of pedestrians crossing the higher volume street during the four highest traffic hours, as presented below:

Pedestrians	Points	Pedestrians	Points
100+	10	40-49	4
90-99	9	30-39	3
80-89	8	20-29	2
70-79	7	10-19	1
60-69	6	0-9	0
50-59	5		

(B) Pedestrians (school)

If the School Warrant (Caltrans Warrant 5) is met, 10 points are assigned.

(C) Bicycles

If the location is identified in the City Bikeway Master Plan, as contained in the Circulation Element of the General Plan, 10 points are assigned.

3. Average Daily Traffic (ADT) Volumes **(Max. Points: 10)**

Points are assigned based on a comparison of the ADT volumes on the intersecting streets, as presented below:

	Side Street ADT					
Main Street ADT	<2,001	2,001-5,000	5,001-10,000	10,001-15,000	15,001-20,000	20,000+
<2,001	0	1	2	3	4	5
2,001-5,000	1	2	3	4	5	6
5,001-10,000	2	3	4	5	6	7
10,001-15,000	3	4	5	6	7	8
15,001-20,000	4	5	6	7	8	9
20,000+	5	6	7	8	9	10

4. Peak Hour Traffic Volumes **(Max. Points: 10)**

Points are assigned based on a comparison of side street traffic volume to main street traffic volume during the peak hour, as presented below:

	Side Street Peak Hour Volume				
Main Street Peak Hour Volume	<100	101-200	201-300	301-400	400+
400	0	0	1	2	3
01 - 600	0	1	2	3	4
601 - 800	1	2	3	4	5
801 - 1,000	2	3	4	5	6
1,001 - 1,200	3	4	5	6	7
1,201 - 1,400	4	5	6	7	8
1,401 - 1,600	5	6	7	8	9
1,601+	6	7	8	9	10

5. Speed

(Max. Points: 5)

Points are assigned in this category to account for the difficulty that motorists may have judging gaps in traffic on high-speed streets. More points are assigned for the higher-speed streets, as presented below:

Posted Speed Limit	Points
50+	5
40-49	4
35-39	3
30-34	2
25-29	1
<25	0

6. Special Conditions

(Max. Points: 5)

Points are added based on special conditions related to the benefits or drawbacks of signalizing an intersection as determined by the Public Works Department.

Activity Centers

(Max. Points: 3)

One point is assigned for each of the following activity centers that generate pedestrian or emergency vehicle traffic and are within 1,000 feet of the candidate traffic signal location:

- School
- Park
- Library
- Employment Center
- Event Center
- Sporting Facility
- Senior Center
- Commercial Center
- Fire Station
- Medical Facility
- High Density Residential

Other Safety Concerns

(Max. Points: 2)

One point is assigned for each of the following safety considerations at the candidate traffic signal location:

- Restricted Sight Distance
- Dense Fog Locations
- Favorable Location for Signal Coordination

New intersections can be added and ranked at any time. To ensure that locations already on the list have rankings that reflect current conditions, the Public Works Department will budget for funds to update traffic counts and prepare new traffic studies such that each location is re-studied every three years. In addition, accident data will be updated for all intersections on the list on an annual basis and incorporated into the ranking analysis.