Evaluation of the Anaheim Advanced Traffic Control System Field Operational Test: Executive Summary

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California PATH Research Report
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CALIFORNIA PATH PROGRAM
INSTITUTE OF TRANSPORTATION STUDIES
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EVALUATION OF THE
ANAHEIM ADVANCED TRAFFIC CONTROL SYSTEM
FIELD OPERATIONAL TEST

EXECUTIVE SUMMARY

Task A: Evaluation of SCOOT Performance

Task B: Assessment of Institutional Issues

Task C: Video Traffic Detection System Evaluation

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Abstract

This Executive Summary provides an overview of the technical and institutional issues associated with the evaluation of the federally-sponsored *Anaheim Advanced Traffic Control System Field Operations Test*. The primary FOT objective was the implementation and performance evaluation of adaptive traffic signal control technologies including an existing second generation approach, SCOOT, and a 1.5 generation control (1.5GC) approach under development. Also selected for implementation was a video traffic detection system (VTDS). The SCOOT evaluation was defined relative to existing, first generation UTCS-based control but using standard field detectorization rather than that normally associated with SCOOT. Furthermore, SCOOT was installed to operate in parallel to UTCS. The 1.5GC system was planned to be efficiently utilized to update baseline timing plans. The VTDS was planned for use as a low cost system detector for deployment in critical areas.

Both SCOOT and the VTDS were implemented with some degree of success, with technical and institutional issues limiting expected performance. Technical issues which limited SCOOT

performance included less than anticipated quality of existing communication and controller systems; corresponding institutional factors included inconsistent project management due to staff changes and delays due to contractual issues. Both SCOOT and a modified version of the VTDS are in current use in selected areas, with plans for system expansion.

Key Words: FOT, adaptive control, institutional issues, VTDS

EVALUATION OF THE ANAHEIM ADVANCED TRAFFIC CONTROL SYSTEM FIELD OPERATIONAL TEST

EXECUTIVE SUMMARY

A systematic evaluation of the performance and effectiveness of a Field Operational Test (FOT) of a Advanced Traffic Control System was conducted from fall 1994 through spring 1998 in the City of Anaheim, California. The FOT was conducted by a consortium consisting of the California Department of Transportation (Caltrans), the City of Anaheim, and Odetics, Inc., a private sector provider of advanced technology systems, with the City of Anaheim as the lead agency. The FOT was cost-share funded by the Federal Highway Administration (FHWA) as part of the Intelligent Vehicle Highway System (IVHS) Field Operational Test Program. The FOT involves an integrated Advanced Transportation Management System (ATMS) which extends the capabilities of existing arterial traffic management systems in the City of Anaheim. The evaluation entailed both a technical performance assessment and a comprehensive institutional analysis.

The City of Anaheim has a population of 300,000 and 150,000 jobs within an area of nearly 50 square miles. Four major event centers with a combined maximum attendance of 200,000 and 15,000 hotel/motel rooms are located within a 3 square mile area of the City. An urban area such as Anaheim has many signalized intersections and short road links, with intersection delay being a significant problem. Speeds or travel times in such urban areas are dominated by queue delay at intersections rather by delays associated with mid-block cruising. Further, Anaheim's arterial street system is often impacted in unpredictable ways due to special event traffic and to ongoing expansion of the City's Convention Center, construction of a new Disney theme park and hotels, and widening of Interstate 5.

The arterial traffic control systems planned for implementation, 1.5GC and SCOOT, respectively represent a partial automation of existing UTCS (Urban Traffic Control System) control and the separate installation of an adaptive traffic control system as an independent control option. Since 1.5GC maintains the existing control system and algorithms, the key evaluation issue involved an assessment of the man-in-the-loop operational format more so than a direct assessment of technical feasibility. Similarly, SCOOT has been installed and evaluated in numerous locations throughout the world, thus, the key evaluation issues involve the limited implementation of SCOOT as an option of Anaheim Traffic Management Center operations, the development of operational policies for SCOOT operation, and the resultant operational effectiveness for defined scenarios (particularly for special events). The third technology, a video traffic detection system (VTDS), was planned as a low cost alternative to existing VTDS technology. It's performance would be measured by it's capability to replace inductance loop detectors currently utilized.

Project evaluation was divided into three tasks: (A) performance assessment of the traffic control technologies, (B) assessment of institutional issues, and (C) evaluation of the VTDS. Each task is summarized below.

Evaluation Task A1: SCOOT's Internal Representation of Traffic Flow

Lead Evaluator: James E. Moore, University of Southern California

Context

The SCOOT (Split, Cycle and Offset Optimizer Technique) adaptive traffic control system was developed in the United Kingdom by three companies, Ferranti, GEC, and Siemens, under the supervision of the Transportation Road and Research Laboratory (TRRL), and is employed extensively in Great Britain. SCOOT is intended to control the operation of systems of signals rather than isolated intersections. The SCOOT traffic model uses data that varies over time, such as the green and red time of the signal and vehicle-presence measurements, together with data that are fixed for the area under control, such as the detector locations, signal stage order, and a variety of other parameters. The SCOOT system collects traffic data from induction loop detectors embedded in the pavement of intersection approaches. The SCOOT system uses this data to project conditions in the form of Cyclic Flow Profiles (CFP), simulating traffic characteristics (stops, delays, flows and queue length) downstream from the detectors. SCOOT's split, cycle and offset optimizers (locally) optimize signal timing by searching for improvements in terms of the CFP. This makes the quality of SCOOT's internal representation of real traffic conditions pivotal to its ability to optimize signal timings. If SCOOT is able to model traffic conditions accurately, then it may also be able to improve these conditions. However, SCOOT cannot function if it cannot model intersection conditions.

Theoretically, the benefits of SCOOT should be highest when traffic flow is heavy, complex, and unpredictable. In the best case, SCOOT both delays the onset of congestion, and provides early relief from congestion. In unsaturated networks, under certain conditions, SCOOT can prevent congestion by delaying it long enough to permit a short duration demand overload to be completely overcome by appropriate adjustments in supply.

The Anaheim Implementation

The core traffic control measure deployed for the Anaheim Advanced Traffic Control System Field Operation Test (FOT) consists of implementation of the SCOOT system, making possible adaptive optimization of traffic flow across subareas of the Anaheim network. A version 3.1 SCOOT system was installed by Siemens for the City of Anaheim network near Arrowhead Pond and Anaheim Stadium, two large special event facilities.

The quality of SCOOT implementation and performance are each constrained by the system's ability to represent traffic conditions at intersections. Anaheim has existing system detectors that are located upstream of the intersection being controlled, at approximately mid-block locations. These system detectors can provide traffic volume counts for use by SCOOT. However, SCOOT is designed to rely on detectors that are located further away from the intersection being controlled. SCOOT detectors are usually locations just downstream of intersections upstream from the intersection being controlled.
The FOT proposal hypothesizes that the existing infrastructure will be adequate for SCOOT implementation; however, there is no certainty that the existing infrastructure will provide optimal (or even acceptable) results. This evaluation investigates SCOOT's ability to represent traffic conditions on approaches given the existing detector pattern. Evaluation Task A.1:

1. assesses the value of Anaheim's existing UTCS inductive loop detectors as effective data sources for SCOOT, and

2. assesses the quality of SCOOT's internal representation of traffic conditions.

Full evaluation of the constraints associated with using nonstandard detector information would require installing upstream loops in a standard SCOOT configuration in addition to existing mid-block detectors, and then comparing SCOOT's operation with different sets of detectors. A fully detectorized installation is not feasible. Consequently the impact of using mid-block detectors is combined with the treatment effects associated with SCOOT.

Our null hypothesis is that SCOOT does not accurately represent traffic conditions at intersections. Rejecting this null hypothesis provides statistically significant evidence that the SCOOT system does indeed meet this necessary condition for improving traffic conditions. It is impossible for SCOOT to meet sufficient conditions for improvements unless this necessary condition has been met. However, necessary conditions might be met even if sufficient conditions are not. Meeting necessary conditions without also meeting sufficient conditions is an inconclusive outcome that leaves open the possibility that SCOOT can provide improvements, but may not if conditions were changed.

Field Observation

A pair of traffic data sets is used to test the quality of SCOOT's representation of intersection conditions. The first is directly from the SCOOT model, provided by collecting loading message reports from the SCOOT system. The second data set consists of empirical field observations, provided by post-processing video tapes of conditions on approaches to intersections subject to SCOOT control. SCOOT model messages provide information regarding how SCOOT assesses traffic conditions of the road network. Estimates of queue length and queue clearance time can be compared with conditions recorded on video. During data collection, a graduate research assistant working in the Anaheim Transportation Management Center (TMC) carefully coordinated the estimated values reported in SCOOT messages with real time videotapes of traffic conditions recorded via TMC cameras.

A real time display of the traffic conditions estimated by SCOOT can also be invoked via SCOOT's Node Fine Tuning Display (NFTD). The NFTD command reports the times at which all approaches to a given intersection begin the green phase, shows the queue length when an approach is green, and the associated queue clearance time. By comparing real time green starts and queue clearance times reported by SCOOT to real time video images, large inconsistencies were identified at some intersections.

Internal Representation Results

As a result of cumulative communication or other system faults, some intersections were unexpectedly being isolated from SCOOT control. In most cases, these faults can be cleared manually, but this requires active intervention on the part of the operator. If faults are actively cleared rather than being permitted to accumulate, the signals involved usually remain under SCOOT control. The number of signals slipping from SCOOT control decreased substantially once Anaheim TMC operators were notified of the need to clear faults as they occurred. This produced substantial data loss for this portion of the evaluation, because SCOOT message data associated with signals subject to cumulative communication faults are meaningless. The conditions reported in such messages diverge from conditions observed via video. As a result, seven of the ten hours of data collected in the Anaheim TMC could not be used because of cumulative SCOOT system errors or related communications problems. The three hours of data remaining still provide statistically significant results. Correlation coefficients between the SCOOT message data and the videotape data were estimated for stops, delays, flows, queue length, and queue clearance times. If the SCOOT system is accurately representing traffic conditions on approaches, then the correlation coefficient between the SCOOT message data and the video data will tend toward unity.

The overall correlation coefficient of 0.86 was estimated between observed flows and flows reported in SCOOT system messages. Coefficients for other traffic indicators are lower, but this is to be expected, because these other measures are derived from flow measures and additional modeling steps are likely to introduce more errors into the values appearing in SCOOT messages. The estimated correlation between observed and SCOOT measures of intersection delay. 0.65, was the lowest value obtained. Approach delay is also more difficult to compute from video observations than the other quantities. The estimated correlation coefficients for observed stops, queue length, and queue clearance times fall between these values. These are aggregate estimates combining data for three intersections. Estimates for individual intersections have more variance, producing some values above and below this interval.

Evaluation Conclusions Relative to Internal Representation

In all cases, it is both qualitatively and quantitatively clear that the data provided by the SCOOT messages covaries moderately to strongly with the data extracted from video tapes. In all cases, the null hypothesis of no relationship between the information in the SCOOT messages and the flows captured on videotapes is strongly rejected. However, the estimated correlation coefficients observed in Anaheim are lower than values obtained in other locations where SCOOT has been deployed. A pre-version 2.3 SCOOT installation in Leicester, England, produced a correlation coefficient of 0.93 for flows, subsequently improved to 0.96. The Anaheim results are most likely a function of nonstandard detector locations. While SCOOT successfully modeled traffic conditions on the intersection approaches observed during the data collection period, there is room for improvement. Improvements could be generated either by changing the locations of detectors, or possibly by adjusting SCOOT's global control settings to try and further compensate for the effect of nonstandard detector locations.

Evaluation Task A2: Traffic Performance under SCOOT

Lead Evaluators: R.Jayakrishnan and MG McNally, University of California, Irvine
James E. Moore, University of Southern California

Context
This component of the Task A technical evaluation focuses on the performance of the identified anaheim sub-network under SCOOT, in terms of delays at the intersections, as well as running times, stop times, and total times on selected routes in the SCOOT network. A standard "before-after" format was adopted focusing on traffic conditions in the PM-peak and evening off-peak both during special events and during non-event traffic conditions.

Field Observation
The Field Observation Plan utilized delay measurement teams posted at intersections and travel time measurement teams driving on specified routes. Ten observation periods were selected for the before study (utilizing existing UTCS control) and ten subsequent observation periods were selected for the after study under SCOOT operation.

Intersection delays were measured at specified times including some measurement periods during the peak (PM) and off-peak (evening) conditions. Resource limitations prevented full-time measurements at all intersections. Intersection delays were calculated by counting the stopped cars at small sample intervals, accumulating totals, and multiplying by the sample interval. The delays were not disaggregated for each turning movement.

Routes for the floating-car travel time studies were selected to obtain a reasonable coverage of the network with sufficient turning movements to capture delay patterns. Five routes were selected, with one being a control study network away from the SCOOT network to capture any unrelated travel pattern or demand variations. Floating car measurements were made for running, stopped, and total travel times by using one driver and one observer in each car. The observers used stop watches and observed times were aggregated and averaged for each route for each observation day.

Traffic Performance Results
The results focused on SCOOT performance under peak and off-peak conditions, under special event and no-events scenarios, and under various ranges of traffic volumes. Key insights derived from the intersection delay analysis include:

1. Based on intersection delays, the SCOOT system in general performed better under off-peak conditions than under peak conditions.

2. Based on intersection delays, the relative performance of SCOOT in comparison to the baseline system improves under special-event conditions compared to no-event conditions for smaller volume intersections, although the reverse occurred for some higher-volume intersections.
3. Based on intersection delays, SCOOT definitely performed very well at two intersections getting heavy exit traffic from the special event location.

4. The SCOOT system produced lower intersection delays in some cases, and higher delays in some cases (but higher delays more frequently), compared to the baseline system. As such there is insufficient evidence to show that it performs significantly worse or better than the baseline system in peak-periods.

5. In cases where SCOOT performed worse than the baseline system relative to intersection delays, the worsening was rarely more than 10 percent; in cases where SCOOT performed better, improvements were normally less than 5 percent.

6. In most cases, delays are comparable between SCOOT and the baseline system. In the few cases where SCOOT performed noticeably worse, special circumstances associated with the project are believed to be contributing reasons.

   The high-volume Katella and State College intersection is a case in point. The delays under SCOOT were lower for three of the four approaches (generally a delay reduction between 4 and 8 percent); however, the overall delay was higher than the baseline case, because one approach was showing delay increases up to 60 percent in the peak period. Further consultation with the City revealed that the timing parameters were likely not optimal. Note that this problem is addressed in the institutional evaluation and perhaps could have been avoided had project management, training, and overall project delays not limited operational experience prior to evaluation.

   Another example of the worsening of results occurred at the low-volume intersection at Cerritos and Sunkist, where strikingly high delays resulted under SCOOT. Further examination suggests that the reason is the incorrect inclusion of this intersection as part of the SCOOT system. The volumes were very low at the intersection, however, it was included in the system as part of the project requirements, since it is an intersection that receives special event exit traffic for short periods. The SCOOT vendor indicated that it would normally not be included in the SCOOT system, as it forces a common signal cycle length which is not appropriate for the intersection, thus causing excessive delays.

7. The SCOOT system, despite the substandard implementation, did not cause any unacceptably higher intersection delays and did not cause any catastrophic problems in

the system, while it produced delay reduction at some intersections.

Only two situations (the likely non-ideal setting of parameters for an approach at a high-volume intersection and the inclusion in the network of an intersection with very small volumes) showed delays that may be considered unacceptable. In almost all other cases, the SCOOT system generally did not show worsening by more than 5 to 10 percent from the baseline, and in many cases showed benefits of a similar range.

8. Travel times on selected routes showed the effect of directional settings in SCOOT. A route's opposing directions which had different travel times under the baseline system showed, in one case, similar travel times under SCOOT, and the reverse in another case.

9. Route travel times under SCOOT showed reductions under 10 percent in some cases and increases under 15 percent in others. On the more circuitous, longer routes covering more of the network, SCOOT showed reductions as much as 2 percent and increases as much as 6 percent. The relative performance against the baseline system was better under no-event conditions than under special event conditions.

Evaluation Conclusions Relative to Traffic Performance

SCOOT amply demonstrated that it can operate in a network with significantly non-ideal detectorization, and control the traffic in a manner that does not cause substantial and unacceptable increases in intersection delays and route travel time increases. In the case of two intersections near the special event traffic generation, the delays were definitely substantially lower than under the baseline system during the sudden traffic egress periods, pointing to SCOOT's ability to make adaptive adjustments. It did not, however, show the kind of benefits shown by other proper implementations of SCOOT around the world, which is perhaps to be expected, considering that the performance comparisons were made against traffic under a baseline system which is considered state-of-the-art in US practice. A proper comparison with an ideally detectorized SCOOT network in Anaheim would have proved very useful, but this was not attempted in this FOT, in part due to SCOOT being accepted as a traffic control system with proven benefits in other installations. The abilities of SCOOT were possibly not fully reflected in Anaheim due also to the minimal time spent in fine-tuning the SCOOT parameters. The reason for the non-ideal fine-tuning were the project time deadlines and the City TMC staff not being fully trained in doing the adjustments within the short period before the field study was conducted. The fact that traffic still performed acceptably under SCOOT and that no serious traffic problems arose, point to SCOOT being certainly a system worth pursuing in Anaheim and other US cities. Further studies on SCOOT implementation in a more elaborate network with less peaking and special-event characteristics than Anaheim may prove beneficial in the future.

Evaluation Task B: **Assessment of Institutional Issues**

Lead Evaluator: MG McNally, University of California, Irvine

Context

This evaluation project is of particular interest not only for its potential to assess the effectiveness of applications of advanced traffic control technologies but also to assess the relative role of institutional issues. Such issues may be categorized in at least two related ways: by the nature of the issue (such as project administration) and by stage in project deployment (baseline, implementation, operations, maintenance, and transferability). A comprehensive assessment of these five major stages of the operational test was approached via two primary evaluation techniques: a systematic "fly-on-the-wall" review of the FOT in terms of institutional catalysts and constraints, and a series of comprehensive interviews of all key project participants. The question of interest was through what structure and methods the technologies in question can be applied so that their effectiveness is neither reduced nor confounded by institutional limitations relative to the programming, implementation, and operations of such technologies.

The institutional evaluation proceeded in parallel with the technical evaluation, however, the former was process-centered versus the effectiveness orientation of the technical evaluation. The five evaluation stages and the associated evaluation goals (which incorporated twenty specific objectives) were:

1. Establish Baseline Institutional Status
2. Assess Institutional Issues in System Implementation
3. Assess Institutional Issues in System Operations
4. Assess Project Transferability
5. Assess Project Maintainability

Field Observation

Data required for the evaluation of institutional issues are substantively qualitative, and as such, may often be somewhat subjective. To minimize bias in the interpretation of the data, data was gathered from alternative sources to see if some consensus, if not still subjective conclusions, could be drawn. The first source of data came via direct observation of project participants, primarily at formal project meetings but also informally over the duration of the project. Formal meetings were documented in meeting minutes which were independently recorded and shared by the Project Manager and by members of the evaluation team. There was a substantial amount of other documentation, associated with both the FOT (proposals, technical memoranda, hardware and software documentation, etc.) and with prior related work in the City. All key project participants were interviewed to gain their opinions on the progress of the FOT and on the relative role of various institutional issues. The interviews were structured around a series of questions addressing anticipated institutional issues. Separate formats were utilized depending on the level of involvement of the interview subject.

Institutional Evaluation Results

The administration of this project proved to be much more time consuming than anticipated, despite fairly extensive prior City experience with complex, multi-agency projects. This was due in part to a lack of precedence in developing legal agreements, and the necessary review and approval delays of city attorneys and councils. Initially scheduled to be completed within 12 months, it was not possible to commence the technical field study until almost 36 months after the evaluation contract was approved.

1. Baseline Findings

   Anaheim had committed to both SCOOT and 1.5GC well in advance of applying for the FOT program. The FOT project represented an opportunity for the City to obtain federal funds in support of their traffic control system. The 1.5GC system may have been included in the FOT to provide additional funds to resolve its operational status. VTDS was brought into the project, in part, as an example of a public-private partnership, rather than as a necessary part of the package. Despite Anaheim's experience in deploying advanced traffic technologies, their baseline timing plans were somewhat dated as were their field controllers and the associated communication systems.

2. System Implementation

   SCOOT: Project delays, attributed to contractual matters and project management issues, began when a SCOOT contractor (Siemens) was selected. There were institutional ramifications of incorporating a new technology into an existing control system, although most of these issues were technically-based. Coordination between the City and Siemens was significantly impacted by the vacancy in the Principal Traffic Engineer position. Despite assumption of responsibilities by other partners, there was a decided lack of City experience and authority during the SCOOT implementation. A Siemens representative dismissed the significance of implementing SCOOT without detectors in standard locations but only because other factors represented a greater concern. SCOOT's inability to fully control offsets and field data communications which were less reliable than anticipated and limited the resultant field performance.

   1.5GC: Despite having an earlier version of 1.5GC in house, the FOT Partners were unable to develop and implement a version of 1.5GC that met the functional requirements originally proposed. Technical problems prevented true "man-in-the-loop" implementation and the system was not used to update baseline parameters.

VTDS: There were no institutional problems associated with the VTDS implementation. The proposed functionality was reduced to presence detection only during the project.

3. System Operations
   A draft operating policy, which included full SCOOT usage except during special events, was implemented only at the end of the evaluation period, thus, no evaluation of operations under that policy was possible. Development of this policy was late due to delays in SCOOT implementation, limited operator training, and very limited operational experience prior to the evaluation period. Having SCOOT implemented in parallel to the existing UTCS-system may have further delayed SCOOT training and operations by impeding operator learning and acceptance.

4. Project Transferability
   It is difficult to establish to what degree advanced technologies which are not primarily off-the-shelf products can be transferred to other locations. This project, however, suggests that, in the case of systems such as the Odetic's VTDS and 1.5GC, products that are not widely deployed are essentially still in the research and development process and can encounter significant delays, cost overruns, changes in product specifications, and unsuccessful implementation. Final deployment is dependent on partner commitment (a modified VTDS was eventually deployed in the City). The institutional lessons learned are themselves transferable. Institutional issues were considered to be critical project limitations, more so than technical limitations per se (lack of knowledge of technical limitations appears more critical than the limitations themselves).

5. Project Maintainability
   Potentially significant costs may compromise project maintainability, costs including TMC and field hardware and software maintenance. The City will have to devote more time to training to continue to operate SCOOT effectively. In the months following the evaluation phase, SCOOT was being utilized to a limited extent within the project area. A modified version of the VTDS was deployed in the construction area neighboring the new Disney theme park. No additional technical evaluations have been completed.

Evaluation Conclusions Relative to Institutional Issues

Two broad conclusions can be drawn. First, the technologies implemented enjoyed some limited success. Second, given these results, institutional and technical factors were identified which were critical in defining this performance. In this sense, the project was successful, although without more extensive observations under normal operating conditions, it would be premature to advise extended implementation in the City or elsewhere. Therefore, no recommendation can be made at this time relative to potential success in transferring the technologies. It is also difficult to fully assess system maintainability issues, due to the field test orientation of the project and the limited observation of system operations. It is estimated, however, that fairly significant increases in traffic management costs would be realized if SCOOT operations were to be expanded. Technical problems were judged as somewhat expected for a project of this scale. Institutional issues associated with project management and contractual matters were judged as unexpected and critical influences on the project. While they were ultimately resolved, their presence nearly terminated the project prior to final implementation.

Evaluation Task C. **Video Traffic Detection System Evaluation**

Lead Evaluator: C.Arthur MacCarley, Calpoly San Luis Obispo

Context

This summary is the result of evaluation Task C "VTDS Evaluation", one of three evaluation tasks covering components of the FOT. The component evaluated under Task C is a video-based vehicle detection system for actuation of traffic signals at intersections. This system, referred to as the Vantage VTDS, was developed and is currently marketed by Odetics Inc. (manufacturer) as a low-cost replacement for inductive loop detectors. It utilizes video cameras mounted on existing luminaires with a view of each of four traffic approaches at an intersection. The product cost for a four-approach intersection is quoted by the manufacturer to be $15,000 for all equipment, not including installation costs.

The FOT provided for the deployment and testing of the VTDS and the support of a comprehensive independent evaluation. During the course of the FOT, the product line was split from the originally-proposed general-purpose detection system into separate freeway monitoring and intersection signal actuation products. Only the intersection product was evaluated under this FOT. The sample VTDS unit provided by the manufacturer for evaluation was a November 1996 release of the commercial product.

The VTDS detects the presence of vehicles in "virtual detection windows" which are established in the video image during the setup procedure, duplicating the function and location of inductive loop detectors. Setup and calibration of the system in the field requires only a standard TV monitor and serial PC mouse. The user interface for the VTDS was found to be unsophisticated but effective. Two useful features are the storage of up to four detection window setup configurations, and the option for remote setup and calibration via a serial port connection.

Field Observation

The evaluation focused on the detection performance of the system with respect to the intended application - the detection of vehicles on intersection approaches for signal actuation purposes. Test metrics and Measures of Effectiveness (MOEs) were developed for this purpose. Deployment specifications restricted our field tests to three signalized intersections at which detection cameras were set up and operated by the manufacturer. Video-taped field data was acquired from these intersection camera feeds, accessible at the manufacturer's facility. A 12-condition video test suite, which represented a typical range of testable traffic and environmental conditions, was assembled from this data, and from video tapes provided by the manufacturer from installations in Texas and Delaware. Documentation was provided by the manufacturer on system operation and setup. Evaluation personnel received training at the manufacturer's facility on the proper setup and operation of the system, and all tests were performed in compliance with these directions.

As means for classifying all possible types of correct or incorrect detection situations, nine vehicle detection event classes and six phase actuation event classes were defined. The VTDS test unit was sourced from the video-tape test suite, and data taken by manual observation of the response of the system for each vehicle passing through the virtual detection windows as displayed on a video monitor. Data was reduced to several composite measures of performance, designed to answer practical questions of relevance to potential users of the system. All test procedures and metrics were approved by Anaheim FOT Evaluation Oversight Team (EOT), which consisted of representatives of all FOT partners.

VTDS Performance Results

Among the test results: 65% of all vehicles flowing through detection windows at the intersections were detected correctly, just as they would be detected by a properly working inductive loop detector. 80.9% of all vehicles flowing through detection windows were detected adequately for purposes of proper actuation of the signal phases. An average false detection and latched detection rate of 8.3% was observed. A condition-weighted average of 64.9% of all red-green transitions, and 64.0% of all green extensions were actuated correctly. Relative to all metrics, the general accuracy of the system appeared to be good under ideal lighting and light traffic conditions, but degraded at higher levels of service and conditions of transverse lighting, low light, night, and rain. We noted problems in robustly handling low vehicle-to-pavement contrast, scene artifacts such as headlight reflections and transient shadows, and electronic image artifacts such as vertical smear, which is typical of CCD (charge coupled device) video cameras.

Evaluation Conclusions Relative to VTDS

A comprehensive review of published literature and product information suggested that there is a lack of evaluation standards and meaningful test data for video-based signal actuation products. This makes direct comparison of the results of the present study with results reported for similar products extremely difficult.

Following their pre-release review of this report, Odetics announced that since the completion of this evaluation, they have observed findings similar to ours in their internal test program, and that both the hardware and software of the VTDS have been subsequently replaced, resulting in significant performance improvements. We have not tested this new system.