

TRB Signal Systems Committee Adaptive Traffic Signals Control Systems Survey

Final Report

UTL – (07/02) – (57)

Principal Investigator:

Dr. Peter T. Martin
Associate Professor
University of Utah

Principal Author:

Rodrigo Disegni
Research Assistant
University of Utah

Date of Documentation:

August 2002

Date of Research:

June-July 2002

This document is proprietary to The University of Utah Traffic Laboratory. The information is privileged and may not be reproduced, copied, or transmitted without the written permission of the Principal Investigator.

August 2002

TABLE OF CONTENTS

Table of Contents	2
List of Acronyms	3
Introduction	5
Agencies Surveyed	7
Results	8
Conclusion	13
References	14
Appendix 1 Survey	15
Appendix 2 Questions summary	16
Appendix 3 Surveys Collected	33

LIST OF ACRONYMS

SCOOT	Split Cycle Offset Optimization Technique
SCATS	Sydney Coordinated Adaptive Traffic System
OPAC	Optimization Policies for Adaptive Control
RHODES	Regional Hierarchical Optimized Distributed Effective System

EXECUTIVE SUMMARY

Adaptive traffic control signal systems (ATCS) are among the most advanced tools that a city can rely upon to optimize their open-street networks. However, only a limited amount of literature exists regarding ATCS's field success. In response, various surveys were performed to agencies that had implemented ATCSs, such as SCOOT, SCATS, OPAC and RHODES. This paper summarizes the information retrieved from those surveys.

Surveys reveal that most agencies are satisfied with ATCSs, as they adapt to varying traffic conditions, such as daily traffic and special events, thus ensuring an improved intersection performance. However, all agencies agree that successfully operating and maintaining the system is a substantial time investment. The agencies also emphasized that to gain proficiency, a person must spend at least one year with the system.

INTRODUCTION

Adaptive signal control systems (ATCS) help optimize and improve intersection signal timings by using real time traffic information to formulate and implement the appropriate signal timings. Without ATCSs traffic controllers use a standard library of timing plans that do not respond to the specific traffic needs at a specific intersection. Theoretically, by addressing real time traffic situations, adaptive signal control systems seem to present an ideal solution. However, traffic engineers considering ATCSs worry about investing in expensive systems without getting optimal results. This worry seems justified because literature on ATCSs performance in America is limited.

To address this lack of information, the Utah Traffic Lab is conducting research on the performance of adaptive control systems in the United States and Canada. We also collected information on the SCOOT system in Chile. The smart systems that have been implemented in these countries are: SCOOT, SCATS, RHODES, and OPAC.

The Transport and Road Research Laboratory (TRRL) developed SCOOT (Split Cycle Offset Optimization Technique) in the United Kingdom in 1981. SCOOT modifies intersection timing-plans based on real-time upstream flow. The model predicts the flow downstream and then changes the green split, offset, and cycle length to minimize stops and delays.

In Australia, the Road and Traffic Authority (RTA) developed SCATS (Sydney Coordinated Adaptive Traffic System). SCATS changes the signal timing based on traffic demand and system capacity and adjusts cycle lengths to maintain a maximum degree of saturation. Monitoring traffic flow in each direction, SCATS selects offset plans from a predetermined library of offset plans. The degree of saturation determines phase split.

The North American versions of adaptive control systems are OPAC (Optimization Policies for Adaptive Control) and RHODES (Regional Hierarchical Optimized Distributed Effective System). Both systems are still under development and are currently being field-tested; therefore, not much information is available on them. The biggest RHODES system in the U.S. is in Tempe, Arizona. This system is a diamond interchange operated by one controller. The largest OPAC system is in New Jersey. That system considers 12 intersections in an arterial corridor.

Since SCOOT and SCATS are the most widely used systems in the US and Canada, we are focusing on these systems, leaving RHODES and OPAC for future consideration.

AGENCIES SURVEYED

We conducted a survey to investigate how different users characterized their experiences with adaptive control systems in networks around the United States. (See Appendix 1 for the complete survey.) The survey included questions about technical aspects and personal impressions of the systems. Respondents communicated answers by phone or email.

We collected information on systems located in the following cities:

Nr	Agency	System	Intersections
1	City of Anaheim, CA	SCOOT	22
2	Orange County, FL	SCOOT	13
3	City of Minneapolis, MN	SCOOT	56
4	City of Toronto, Canada	SCOOT	300
5	Santiago, Chile	SCOOT	300
6	Oakland County, MI	SCATS	575
7	Minnesota DOT	SCATS	71
8	City of Tucson, AZ	RHODES	Experimental
9	City of Tempe, AZ	RHODES	1
10	New Jersey DOT	OPAC	12

RESULTS

Of the 10 completed surveys, five addressed SCOOT, two SCATS, two RHODES and one OPAC. Most of the RHODES information indicates that the system is still in experimental stages. Because the RHODES systems are small and inexperienced, this study will not include them, however, those survey responses are available in the Appendix 3. Although the OPAC system in New Jersey is 12 intersections, it will not be included until we get more systems running that can provide more information.

Primary Control Signal

None of the SCOOT systems in this study work as the primary traffic signal system. Rather, they work attached to different signal systems such as UTCS, NEMA TS-1, T 2000C, Siemens UTC V21.4. Of the many controller choices available, some interact better with SCOOT than others.

The two SCATS systems in this study function as the principal traffic signal system because SCATS is a fully contained system that does not need a traffic signal system.

Level of Effort on setting up the System

The level of effort required to implement the system is directly related to network size and infrastructure. Anaheim, California implemented SCOOT on a 22-intersection corridor in only two months. However, for a 56-intersection network, Minneapolis needed 18 months to implement SCOOT. Oakland County, Michigan took 12 months to make SCATS operational on the first 28 intersections, but the system has since reached 575 intersections. The variables of different systems make quantifying the amount of effort difficult. We cannot clearly define which system required a higher level of effort, due to each system's differences.

Understanding the System

Adaptive control systems are very complex in operation, and respondents believe that to understand these systems general traffic engineers need at least four to six months, while an experienced signal-timing engineer needs about two months. These estimates seem to only indicate the time needed to understand the system and are far the time needed to get proficient at it. Steve Kemp, SCOOT user from the City of Toronto, Canada, described the amount of time needed to understand the system as "Significant. Extensive training required. Years of hands on experience to become proficient with the system."

Detection

One important point to consider in the operation of adaptive systems is the location and type of the system detection. Most SCOOT users locate their loop detectors 300 to 350 feet upstream from the stop bar. However, different cities have varied this location. Anaheim installed loops at the departure side of the intersection, which sometimes is less than 7 seconds or more than 14 seconds upstream from the intersection. They do not believe that the loop distance is an issue. In any case, the rule of thumb is to place the loops at least 7 seconds upstream from the intersection. Chile, however, must confront a different problem: high volumes of public transport as well as high levels of bus stop activity. Chilean traffic engineers have found that it is better to locate detection loops downstream of bus stop locations. SCATS, however, requires detectors at the stop bar of an intersection. In the case of the SCATS system operating in the Oakland County with 575 intersections, 80% of the detection is by Autoscope video detection and the rest by loop detectors located at or close to the stop bar.

What does the system handle well?

Respondents were asked which traffic operation features adaptive control systems handled well. In SCOOT, respondents like the automatic double cycling feature. This feature allows minor intersections to go into double cycling whenever the overall system sees an advantage.

Respondents also like SCOOT's green wave that allows a platoon to advance in a corridor; this feature can be used to give a green wave to for example, emergency vehicles. SCOOT also handles unexpected traffic conditions well, such as adverse weather, large events and sudden increases in the demand. The SCOOT user in Orange County mentions that at large conferences they needed manual traffic control by police, which costs about \$80,000 per major event. Now, SCOOT efficiently handles that labor, saving money for the city.

Many SCOOT users also appreciate the smooth transition from one cycle length to another. Although this system characteristic is often considered efficient, some respondents said that sometimes when the change on the demand is fast, the reaction on the system is too slow, in which case some parameters can be adjusted to make the operation faster.

Criticisms of SCOOT include its inability to handle closely spaced signals, where historical demand rather than real time information should be used. Whenever

there is a mid block flow, detectors must be carefully set in the appropriate place otherwise it is better to use historical demand.

One of the most frequent complaints about SCOOT is the user interface; it is difficult to use and the fact that traffic terminology differs from the terminology used in the U.S., makes everything more difficult to understand.

In regard to SCATS, engineers mention that it can handle well changes in volume. SCATS also functions efficiently under unexpected conditions and left turns, providing more green time when the left pockets are too crowded.

In regard to Progression, engineers were unsatisfied with SCATS performance. In the words of one respondent, *“Progression is the least smart”*. Not all the controllers work as well with SCATS, and thus one must carefully select the proper controller. In any case, this feature seems to have improved in latest version of the system.

The respondents were also asked what they would have done differently during the system’s implementation. In general, they were satisfied how everything was done, but they all agreed the importance of being careful with detectors, and defining what detectors should be implemented, because post-implementation changes are a significant project. One direct result of this project was the emergence of communication and coordination among all the different departments involved in the installation the system.

CONCLUSION

We can conclude that overall, the impression of adaptive traffic systems is satisfactory, and these systems improve as they respond to real time conditions. There is high investment in time as well as in commitment by all the parties (contractor, city staff, traffic engineers, etc) involved in order to make the system successful. The level of effort involved in the setup of a system can be as high as one year depending on the size of the corridor or network. Understanding the system can take several months to become proficient, most likely more than a year. How the system should be built is not a secret. For example with SCOOT most respondents use loop detectors located at 300 feet from the stop bar on the other hand SCATS requires loops at the stop bar or close to it. In general, controllers must be carefully chosen, as it is evident that some controllers are better suited to work with adaptive systems than others.

REFERENCES

1. Experience of Signal Control Agencies with Adaptive Control in North America, Mohammed Hadi Long Island, CA 2000

APPENDIX 1 SURVEY

Adaptive Traffic Signals Control Systems

QUESTIONS

Date:

Name:

Agency:

Phone Number:

Adaptive System: SCOOT – # intersections in an arterial corridor

1. Initial comments about System.
2. If it is an add-on feature (SCOOT, RHODES) what is your primary traffic signal system?
3. When was the System installed and operational (date)? When do you expect the System to be operational?
4. What was the level of effort, by the System contractor, to make the System operational (days, months)?
5. What was the level of effort by City staff to make the System operational?
6. What was the level of effort by City staff to understand the System operational and be able to use it on a day by day basis?
7. Where are the system detection loops located (distance from intersection)? What is the roadway design speed?
8. What are the traffic operation features that the System handles well (give 2 or 3 examples)?
9. What are the traffic operation features that the System does not handle well (give 2 or 3 examples)?
10. In hind sight what would you have done differently during the implementation of this System?

APPENDIX 2 QUESTIONS SUMMARY

Nr	Agency	System	Intersections
1	City of Anaheim, CA	SCOOT	22
2	Orange County, FL	SCOOT	13
3	City of Minneapolis, MN	SCOOT	56
4	City of Toronto, Canada	SCOOT	300
5	Santiago, Chile	SCOOT	300
6	Oakland County, MI	SCATS	575
7	Minnesota DOT	SCATS	71
8	City of Tucson, AZ	RHODES	Experimental
9	City of Tempe, AZ	RHODES	1
10	New Jersey DOT	OPAC	12

1. Initial comments about System.

Nr	
1	<i>The SCOOT graphics interface definitely needs improvement. There needs to be a better integration between SCOOT and the UTCS system. Support by Siemens and Eagle out of London and Austin has been good.</i>
2	<i>Excellent signal operation for areas of unpredictable traffic conditions, including convention centers, tourist attractions, shopping malls, and university campuses.</i>
3	<i>The SCOOT implementation included 56 intersections under SCOOT control in a downtown grid network. Of these 56, only 6 could be considered to be an arterial with a definite major street and minor street.</i>
4	<i>Can have significant on-street benefit (particularly during off-peak, peak period shoulders and special events. However, the benefit can only be realized if the system is properly setup and maintained.</i>
5	<i>The Traffic control Operation Unit's main objectives are the administration, maintenance and operation of Santiago, Chile's traffic control system. This system controls and coordinates the operation of 1,800 traffic lights among 34 districts. The traffic control system operates in real time, and second after second, information is exchanged between the central computers (5 computer using an Ethernet network) and each traffic controller. To ensure its success, the system uses telephone networks, which are used only in a point-by-point network.</i>
6	
7	<i>SCATS was originally chosen due to its ramp meter component, its complete signal system package and good vendor support. The vendor was very willing to work with the State. This was an FHWA Operational Test. The other Adaptive System in the area (SCOOT) was an add-on component to an existing signal system. MinnDOT did not see same level of support from SCOOT vendor. Over time Neil Gross with TransCore has provided good support and the dial up service has been very effective at resolving problems.</i>
8	<i>(from an email) Don, you are the 2nd person asking for information on RHODES. Unfortunately, I don't have a lot of information for you. We've been working with the University providing them equipment and a test bed for the development but to date we have no running RHODES controllers on Tucson streets. As a result we don't actually have any hands on RHODES experience. I know they are finalizing some of the peer to peer communication stuff and we are hoping to have RHODES on the street in the near future.</i>

	<i>Other than that about all I can tell you is that simulation stuff that we've seen does show a significant increase in traffic throughput with RHODES.</i> <i>I know it will probably be to late for you, but get back with me towards the end of this year, 1st of next and I should have more information for you.</i> <i>Just as an FYI on your loop questions, we have Autoscope at all of the intersections where we plan to test RHODES. Again, at this time we don't know how well these will work for what RHODES needs.</i>
9	<i>Jim shared the following comments. RHODES is a research project. Jim helped develop the RHODES system. RHODES has not been deployed anywhere at this time. The RHODES project in Tempe is a diamond interchange operated by one controller. He chose to have no skip phases for driver expectancy. The setup has 16 system detectors used from the City's Computran traffic signal system. The 16 system detectors give an upstream advance planning time of 45 seconds. Eight Autoscope cameras were installed for stop bar/queue detection. The City initially installed the System and it operated on average as well as the time of day plans. City then made operational enhancements and the RHODES performance improved. City plans to perform an evaluation test on July 31st and August 1st.</i>
10	<i>When running, it is a very efficient system. However, the system was difficult to maintain due to the complexity of the hardware components and the physical infrastructure.</i>

2. If it is an add-on feature (SCOOT, RHODES) what is your primary traffic signal system?

Nr	
1	<i>Primary traffic signal system is UTCS Enhanced. This is a co existing system where the one controller operates in either the UTCS operation or the SCOOT operation. The City's CSC T1 controller has full upload/download capabilities. As a future direction, the City will change out all its controllers to 2070s. The City currently has about 25 2070s in the field. The City is also looking have SCOOT operational citywide and replacing the UTCS system with a Siemens UTC system and Eagle interface.</i>
2	<i>NEMA TS-1 (Eagle)</i>
3	<i>Primary system: T2000C (central computerized traffic control system)</i>
4	<i>SIEMENS UTC V21.4 is the base system that SCOOT runs on in Toronto. We have two other systems that do not run SCOOT Econolite ARIES (9 Intersections) and our own system that we refer to as MTSS (Main Traffic Signal System) which controls approximately 1600 traffic signals.</i>
5	<i>The system used is UTC Siemens, developed by Siemens Traffic Controls Ltd. Of the 1,800 existing traffic lights, 1,400 operate with fixed timing plans, 300 operate with SCOOT and the rest are fully actuated.</i>
6	<i>Not applicable.</i>
7	<i>SCATS is a fully contained system. MinnDOT will be looking at purchasing Eagle or Econolite intersection controller for future use with the System. Delta (Australian) controllers are no longer available. These NEMA controllers will be a big improvement for the maintenance staff. MinnDOT area technicians are not comfortable with the 170E controllers.</i>
8	
9	<i>RHODES uses the Computran system for its system detection information. An interface program was written to collect the detector data from the Computran System and pass it to an Icons System which then forwards the detection information to the 2070 at the intersection. The System does not need Icons to function, it is merely an interface.</i>
10	<i>The system was designed to operate traffic responsive under OPAC with a Multisonics "OSAM" closed loop system as backup.</i>

3. When was the System installed and operational (date)? When do you expect the System to be operational?

Nr	
1	<i>System was installed in April 1997 and operational in July 1997.</i>
2	<i>Phase I: May 2000 (7 signal) Phase II: November 2001 (6 signals) Phase III: Expected 2003 (7 signals)</i>
3	<i>The SCOOT system was installed and operational as of October 1998.</i>
4	<i>Original pilot project in 1992 (75 intersections). Major expansion in 1996 and annual program to expand further since then.</i>
5	<i>The project "Construction of an Area Traffic Control System" started in early 1994. From that date on, it was necessary to begin several projects that need to be done either before or simultaneously with the control systems installation. Among the most important projects was the standardization of traffic light installation, the replacement of most of the controllers, and the installation of the communication networks. We also had to complete all the traffic engineering analyses in order to define both the operation mode as well as the timing plan, that we intended to use in the different traffic lights networks. The system was installed in 1997 and was finished by 1998. In that year we had running the operation center, and the complementary systems. The complementary systems are a closed circuit TV network, variable message boards, a geographic information system, and a priority system for emergency vehicles.</i>
6	<i>June 1992.</i>
7	<i>This freeway corridor project was an FHWA operational test which started implementation in early 1995. The full system became operation in 1998.</i>
8	
9	<i>System installed December 2000. System is still a research project. Expect to install a corridor test next spring. Due to the fact that this implementation was a joint research effort with the City considerable staff time was needed to make the intersection operational.</i>
10	<i>March 1996. However, the fiber optic backbone and system detectors have not been satisfactorily maintained so the system is currently not operational. I believe that there was also a Y2K issue with the 170 controllers that also created maintenance headaches.</i>

4. What was the level of effort, by the System contractor, to make the System operational (days, months)?

Nr	
1	<i>System contractor took approximately 5 - 7 weeks to get SCOOT operational once the controller and detection modifications were installed.</i>
2	<i>Approx. 3 months.</i>
3	<i>The system contractor was responsible for determining the optimum location for the SCOOT system detection, while simultaneously training City staff in the determination of detector siting. This activity required approximately two weeks for the 135 detector locations. The system contractor also made software modifications to the existing system and integrated the SCOOT system, taking approximately 18 months for these efforts. Post-installation training was also provided as described in the answer to question 6.</i>
4	<i>Several Months Effort.</i>
5	<i>The setup of 50 intersections took approximately 1 year while the full system's took 4 years</i>
6	<i>One year for first 28 intersections.</i>
7	<i>Need to prepare the vendor with good geometric data and turning movement data. For SCATS, a turnkey operation should take a couple of months. The training of staff requires a number of follow up visits.</i>
8	
9	<i>Getting the 2070 to work in a TS2 cabinet took the greatest amount of time. A lot longer than expected. To get RHODES operating at the intersection took from 2 weeks to a one month effort for the System contractor.</i>
10	<i>There was a lot of difficulty mainly because this was our first attempt to interconnect a system using fiber optic cable and the software for the system was being developed concurrent with the installation of the hardware.</i>

5. What was the level of effort by City staff to make the System operational?

Nr	
1	<i>The City effort was approximately 7 - 10 weeks.</i>
2	<i>Approx. 1 month.</i>
3	<i>The primary efforts of the City to make the system operational were the addition of detection at 65 intersections and modifications to or replacement of controller cabinets at nearly all intersections. The detection (video) was installed by an electrical contractor in a single construction season (approximately 6 months). 65 intersections were detectorized, including the 56 intersections controlled by SCOOT and 9 additional "SCOOT boundary" intersections. The controller cabinet modifications and replacements were performed by the City over an 18-month period – driven by the schedule of the software contractor. This time could have been shortened considerably if necessary.</i>
4	<i>Several Months Effort + Continuous effort to maintain.</i>
5	<i>We estimate that a new system user of the system will learn the basics in three months</i>
6	<i>It took a great deal of coordination and effort across several divisions including, signal engineering, traffic engineering, and signal maintenance.</i>
7	<i>Significant effort in the beginning. This operational system test had a lot of communication equipment issues in the beginning. Between construction problems which cut communication lines, the use of multiply communication mediums and the first use of the system by multiple agencies created a significant effort for staff to overcome and make the system operational. There were also system software upgrades. This was a beta test site for the communications effort.</i>
8	
9	<i>Due to the fact that this implementation was a joint research effort with the City considerable staff time was needed to make the intersection operational.</i>
10	<i>The local City staff was not involved. However, State staff spent numerous hours troubleshooting and configuring the system hardware.</i>

6. What was the level of effort by City staff to understand the System operation and be able to use it on a day by day basis?

Nr	
1	<i>The level of effort varies with the type of Engineer. An experienced signal timing Engineer can learn the System and be comfortable with it in about two months. A general traffic engineer will require about 4 – 6 months.</i> <i>The level of effort also varies with the graphical user interface. The current System version requires knowledge of the UK traffic terminology. A newer version predicated on US traffic terminology would greatly reduce the learning effort.</i>
2	<i>The contract included five-day operation training to County staff.</i>
3	<i>The City had two engineers working full-time side by side with (usually) one or (sometimes) two SCOOT experts provided by the SCOOT supplier for over two months immediately following installation of the system. The training included classroom -type (5%) introductory material, hands-on data preparation (15%), and hands-on field timing development and fine- tuning (80%). After the initial training and after the City had used the system for six months, the SCOOT supplier provided an additional two weeks of personnel time on-site to deal with any additional issues which had arisen and to review the work of the City personnel.</i>
4	<i>Significant. Extensive training required. Years of hands on experience to become proficient with the system.</i>
5	
6	<i>SCATS is a high level signal system. The complexity is directly proportional to its ability to move traffic. As a result, the system take many years to learn, and even more to become truly proficient. New Windows based software has made training easier, but the underlying philosophy and logic is still complex. SCATS is very powerful and an excellent system, it just takes time to fully understand.</i>
7	<i>At this point the effort is not significant. MinnDOT uses part time college students to assist with the system work effort. These interns are given three days training and then left on their own to work with the system. The level of effort is to learn and use SCATS is comparable with any other closed loop system. Obviously the more you use it the more proficient you become.</i> <i>The new user GUI interface is a huge improvement over the previous system interface. This contributes greatly to the intern's ability to learn and use the system</i>

8	
9	<i>For a new installation by another agency it would probably take a couple of months to learn how to operate RHODES. This is on par with the implementation of any new System, Series 2000 etc.</i>
10	<i>The local City staff was not involved. However, State staff were trained by the software developer on system operation and control. A lot of time was also spent after training using the system and becoming familiar with all of its capabilities and report generation characteristics.</i>

7. Where are the system detection loops located (distance from intersection)? What is the roadway design speed?

Nr	
1	<i>Anaheim in its Federal Field Operational Test (FOT) wanted to test the existing system loop detection locations (350 feet from the stop bar). The practice now is to install loops on the departure side of the intersection which may be less than the recommended 7 seconds or more than 14 seconds. City does not believe that too short or too long a distance is an issue.</i>
2	<i>Generally, 100 meters upstream of the stop bar, unless geometry would not allow.</i>
3	<i>In general the system detection loops are located just over 300 feet upstream of the stop line, which for our grid system, placed them just downstream of the previous intersection. The roadway design speed is 30 mph. These distances represented a minimum recommended distance (7 seconds from detector to stop line), and longer distances were used wherever possible.</i>
4	<i>See attached detector drawing detector placement is determined based on a large number of factors. Road design speed varies from arterial to arterial. Detectors are placed a minimum of 7 seconds of travel time in advance of the stopline if possible.</i>
5	<i>There are two types of loops according to their function: detection and occupancy, each located at different street locations. Detection loops, needed for traffic light's, which operate under vehicle demand, are located 10 to 12 meters (32-39 feet) from the stop line. The dynamic control loops needed to optimize timing plans (cycles, faces and offsets) according to vehicular flow is located at the beginning of the link. However its final location depends on the presence of bus stops, pavement quality, parking lots, mid block flow (gas stations, parking, small streets, schools, etc) link length, network configuration, distance to communication networks, etc The designed speed of streets is not relevant to the placement of dynamic control loops. In order to have a loop up and running we have to calibrate some parameters in the data base. To calibrate, we have to incorporate link's data such as time at free flow speed from the loop to the stop line, time that the link needs to clear out if the link is full, loose time, gained time in yellow and link's capacity. These parameters plus the calibration itself imply the design speed of the street.</i>
6	<i>About 80% of our detection zones are Autoscope, the rest are loops. They are all located at the stop bar.</i>
7	<i>MinndOT install 6x15 foot loops at the stop bar or close to it. Because of winter snow, technicians go out and monitor where motorists stop</i>

	<i>and install the loops accordingly. MinnDOT retains the back/advance loops at the intersection in case emergency situations require that technicians swap controllers and install a NEMA controller to keep the intersection operational.</i>
8	
9	<i>Sixteen system detectors are located upstream from the test intersection, spaced at a distance up to 45 seconds at free flow speed. These are primarily existing system detectors from the City's Computran System. New system loops were placed on the freeway off-ramps. Eight Autoscope cameras were installed to handle queue detection at the stop bar. The size of the detection zone emulates a 6 x 50 foot detection zone.</i>
10	<i>It varied due to the distance between intersections. Because the software recognized speed as well as occupancy, every effort was made to make sure that the loops were located such that the vehicles would be traveling at normal speeds so that platoons of vehicles could be recognized and processed by the software. On average, approximately 50 yards from the intersection.</i>

8. What are the traffic operation features that the System handles well (give 2 or 3 examples)?

Nr	
1	1) City likes the automatic double cycling features. Minor intersections can be programmed to go into double cycling when the overall system operation sees an advantage. At times, this may require an increase to the background cycle length. 2) SCOOT has a green wave feature that would allow the signals to be set such that a platoon could advance along a corridor unimpeded or for use with emergency vehicles.
2	During President Bush's visit to make a speech at the convention center last November, the entire corridor was closed for 30 minutes and traffic backed up for miles behind the barricades. When the street was open, both audience traffic exiting the convention center and traffic waiting behind the barricades cleared the area within 20 minutes. During the PGA Merchandise Conference last January, 70,000 attendees were able to easily ingress and egress the convention center without manual traffic control by police. In previous years, more than \$80,000 used to be spent on manual traffic control during each major event.
3	Adjusts splits and offsets rapidly in response to changes in demand levels and in the source of those demands from upstream intersections. Smoothly transitions from one cycle length to another, causing minimum disruption to traffic flows. The system makes a large number of tools available to the user to accomplish the desired operation in a number of ways. Automatically transfers intersections into or out of coordinated zones, depending on traffic activity levels and optimum cycle lengths.
4	Signal timings during peak period shoulders, off peak, weekends, special events, adverse weather conditions.
5	The system has worked well since its implementation. It has demonstrated its monitoring capacity, failure detection, modification of the timing plan on line (a permanent change or temporal change as a response to an incident), generation of congestion level graphs, management of count station, archive and management of data base, holidays, contingency plans, etc. Making the network operates successfully despite the special aspects required by Santiago's network operation. For example, the system has handled the modifications in operations well, specifically their reversibility of some of them according to the time of the day.

	<i>Also, the system has permitted the implementation of contingency plans in response to special events such as reduction in the flow due to environmental emergencies and the opening of exclusive roads. The dynamic control has operated well in networks with the following characteristics:</i> <i>Networks with a low or medium percentage of transit, especially with small bus stop activities; networks with high flow variability during the day, especially at unexpected times of the day; networks close to the saturation point where small variation in the flow makes important effect in congestion; and intersections and arterials that operate well under dynamic control where there is sporadic variation in the flow, for instance the result of incident, work on the road, vacation period, etc.</i>
6	<i>Handles left turns and variable volume levels very well. Also good at responding to congestion at unusual times.</i>
7	<i>1) Masterlink has nice tools which allows the system to be monitored and the new GUI presents the information in a useful format. 2) SCATS has a lot of capabilities which can be tapped for special conditions. 3) The ability of the SCATS to respond to the actual field conditions. This freeway corridor has a lot of commercial and retail development which has traffic patterns changing all of the time.</i>
8	
9	<i>1) Responds well to the varying traffic flow on a cycle by cycle basis with cycle length changing each time. 2) Responds well to incidents or construction where the capacity of the intersection is all of a sudden reduced.</i>
10	<i>The ease of which the parameters of the software could be changed. It did decrease travel time on the corridor but due to the geometric constraints of the corridor, this decrease was not all that noticeable.</i>

9. What are the traffic operation features that the System does not handle well (give 2 or 3 examples)?

Nr	
1	<i>1) Under certain lane configurations and signal spacing (limited storage space on closely spaced signals) SCOOT does not perform well.</i> <i>2) SCOOT user interface needs improvement. Integration with the existing UTCS graphics should have been performed with the initial installation.</i>
2	<i>Special detector placement is required for short links less than 100 meters, otherwise a minimum fixed green time must be provided for those links.</i> <i>Minimum cycle length must cover pedestrian clearance in all directions, resulting in unnecessary delays for side streets when vehicular & pedestrian volumes are low.</i> <i>Phasing sequence is fixed in all times regardless of traffic patterns, resulting in less than optimum bandwidth along the arterial.</i>
3	<i>When there are two separate, approximately equal movements feeding a downstream link the system has difficulty assigning an offset to the intersection feeding the link.</i> <i>The system has some difficulty dealing with short blocks. Since the recommended travel time between the detector and the stop line is 7 seconds, short blocks require special handling, using historical demands rather than real-time demands.</i>
4	<i>Protected/permissive left turn phasing where gaps in opposing flow is not predictable.</i>
5	<i>As mentioned before, the system has complied with the necessary requirements needed to provide an efficient traffic management. Social economic evaluations show that the investment has been recovered in less than a year, which means that this is a project with high social revenue.</i> <i>One aspect that can be improved is the fact that when an intersection is unhooked from the main system due to a failure on the phone line, there is no way to find out if the intersection is off. In any other case, the system can show when the intersection is off.</i> <i>We have also evaluated networks with high presence of public transport (over 300 buses/hr) or with a high bus stop activity, the benefit of the dynamic control system are small respective to preset timing plans.</i>
6	<i>Progression is the least “smart”. Tables need to be set up by the engineer and the system picks a value based on conditions. If the tables are wrong, the progression will be poor.</i>

7	<i>1) Generation of the controller personalities is kind of a pain. It could be made more user friendly. 2) Some of the features in the old system are not fully implemented in the new GUI system. This causes new users and casual users a problem. 3) The Delta 3 (Australian) controller interface is not user friendly. Technician are used to NEMA controllers.</i>
8	
9	<i>Jim expressed that he did not have enough experience to know what the System does not handle well. Jim expressed that current RHODES system 1) does not have the ability to figure upstream vehicle speed and density and 2) time to the stop bar from a system detector is calculated not measured.</i>
10	<i>Due to the geometric constraints of the corridor and the traffic congestion that is present, it was difficult to analyze the overall performance of the system. Due to the amount of fiber optic cable and system detectors installed, it was very difficult to maintain.</i>

10. In hind sight what would you have done differently during the implementation of this System?

Nr	
1	1) When the SCOOT system was installed there should have been more effort on the graphical user interface (GUI). Currently there is a lot of information missing. 2) There was a lack of foresight to integrate the real time graphics into the SCOOT features.
2	Prior to the validation process: Construction inspectors should verify detector configuration. System operators should test communication equipment. County staff should be trained to design and validate the system for future expansions or troubleshooting.
3	With the implementation, I cannot think of anything which I would have done differently. For the project as a whole, the selection of and monitoring of the evaluation consultant could have been better. Several mistakes were made by the consultant in gathering before-and-after data, rendering the project report relatively useless with regard to performance of the system. In-house evaluation of the system performance would have been better but was not an option due to limited City staff availability and the sources of project funding.
4	Wireless detection. Do not change your “normal” traffic engineering strategies or overall approach to signal timing just because you are going with adaptive control. For example, set maximum cycle times and phase durations that you are comfortable with
5	Under a long run perspective and without budget constraint, we would have studied more in depth better ways to communicate between the traffic light and the control center. Another point, that already was redesigned, was the communication system for traffic light controllers. In the beginning we had a group of 8 controllers connected, so when we had a failure on the line we had all of them disconnected at once. Since the number of traffic lights that were going off was too high, we redesigned the communication system, connecting just one traffic light independently that has since been more stable and without major inconveniences. In regard to the dynamic control system, we have found from the last evaluations, that network configuration must be studied with more detail. We also have found that the dynamic control loops must be built downstream from bus stops, and if necessary, they must be moved. This is an important subject in Santiago due to the high presence of public transport.
6	We use leased phone lines. We should have gone with fiber or other

	<i>medium that would have allowed us to easily install CCTV and bring back our Autoscope images. We could then have programmed the Autoscopes from the TOC and been able to respond quicker to detector issues. We also used the Australian phasing set-up. We have now switched to the standard NEMA with even numbers for thru movements and odd number load switches for left turns. We also should have gone with lamp monitoring. This was an extra device and relatively expensive but would have been very beneficial.</i>
7	<i>Would have worked on smaller implementation chunks. Went from 15 intersections to 68 intersections in one jump. It is better to work incrementally. Get a reasonable number up and operational which is based on staff availability and commitments then movement to the next reasonable sized chunk.</i>
8	
9	<i>Would have worked out hardware problems ahead of time. Jim had no idea how difficult it would be to get a 2070 controller working in a TS2 cabinet. There was also a lot of effort on interface work between the Computran System detectors, Icons, 2070 controller, TS2 cabinet and the RHODES software which operates in the 2070 controller.</i>
10	<i>Utilize system hardware that has been proven in the field under the harsh environmental conditions that exist. Fully bench test the system hardware and software before implementation in the field. Set up a better maintenance program so that the system can be adequately maintained.</i>

APPENDIX 3 SURVEYS COLLECTED

Adaptive Traffic Signals Control Systems QUESTIONS

Date: 8/31/01

Name: John Thai

Agency: City of Anaheim

Phone Number: 714-765-5294

Adaptive System: SCOOT – 22 intersections in an arterial corridor

1. Initial comments about System.

The SCOOT graphics interface definitely needs improvement. There needs to be a better integration between SCOOT and the UTCS system.

Support by Siemens and Eagle out of London and Austin has been good.

2. If it is an add-on feature (SCOOT, RHODES) what is your primary traffic signal system?

Primary traffic signal system is UTCS Enhanced. This is a co existing system where the one controller operates in either the UTCS operation or the SCOOT operation. The City's CSC T1 controller has full upload/download capabilities. As a future direction, the City will change out all its controllers to 2070s. The City currently has about 25 2070s in the field. The City is also looking have SCOOT operational citywide and replacing the UTCS system with a Siemens UTC system and Eagle interface.

3. When was the System installed and operational (date)? When do you expect the System to be operational?

System was installed in April 1997 and operational in July 1997.

4. What was the level of effort, by the System contractor, to make the System operational (days, months)?

System contractor took approximately 5 - 7 weeks to get SCOOT operational once the controller and detection modifications were installed.

5. What was the level of effort by City staff to make the System operational?

The City effort was approximately 7 - 10 weeks.

6. What was the level of effort by City staff to understand the System operation and be able to use it on a day by day basis?

The level of effort varies with the type of Engineer. An experienced signal timing Engineer can learn the System and be comfortable with it in about two months. A general traffic engineer will require about 4 – 6 months.

The level of effort also varies with the graphical user interface. The current System version requires knowledge of the UK traffic terminology. A newer version predicated on US traffic terminology would greatly reduce the learning effort.

7. Where are the system detection loops located (distance from intersection)? What is the roadway design speed?

Anaheim in its Federal Field Operational Test (FOT) wanted to test the existing system loop detection locations (350 feet from the stop bar). The practice now is to install loops on the departure side of the intersection which may be less than the recommended 7 seconds or more than 14 seconds. City does not believe that too short or too long a distance is an issue.

8. What are the traffic operation features that the System handles well (give 2 or 3 examples)?

*1) City likes the automatic double cycling features. Minor intersections can be programmed to go into double cycling when the overall system operation sees an advantage. At times, this may require an increase to the background cycle length.
2) SCOOT has a green wave feature that would allow the signals to be set such that a platoon could advance along a corridor unimpeded or for use with emergency vehicles.*

9. What are the traffic operation features that the System does not handle well (give 2 or 3 examples)?

*1) Under certain lane configurations and signal spacing (limited storage space on closely spaced signals) SCOOT does not perform well.
2) SCOOT user interface needs improvement. Integration with the existing UTCS graphics should have been performed with the initial installation.*

10. In hind sight what would you have done differently during the implementation of this System?

*1) When the SCOOT system was installed there should have been more effort on the graphical user interface (GUI). Currently there is a lot of information missing.
2) There was a lack of foresight to integrate the real time graphics into the SCOOT features.*

Adaptive Traffic Signals Control Systems QUESTIONS

Date: 7/3/02

Name: Hazem El-Assar

Agency: Orange County, FL

Phone Number: (407) 836-7866

Adaptive System: SCOOT – 13 intersections in an arterial corridor

1. Initial comments about System.

Excellent signal operation for areas of unpredictable traffic conditions, including convention centers, tourist attractions, shopping malls, and university campuses.

2. If it is an add-on feature (SCOOT, RHODES) what is your primary traffic signal system?

NEMA TS-1 (Eagle)

3. When was the System installed and operational (date)? When do you expect the System to be operational?

Phase I: May 2000 (7 signal)

Phase II: November 2001 (6 signals)

Phase III: Expected 2003 (7 signals)

4. What was the level of effort, by the System contractor, to make the System operational (days, months)?

Approx. 3 months.

5. What was the level of effort by County staff to make the System operational?

Approx. 1 month.

6. What was the level of effort by County staff to understand the System operational and be able to use it on a day-by-day basis?

The contract included five-day operation training to County staff.

7. Where are the system detection loops located (distance from intersection)? What is the roadway design speed?

Generally, 100 meters upstream of the stop bar, unless geometry would not allow.

8. What are the traffic operation features that the System handles well (give 2 or 3 examples)?

During President Bush's visit to make a speech at the convention center last November, the entire corridor was closed for 30 minutes and traffic backed up for miles behind the barricades. When the street was open, both audience traffic exiting the convention center and traffic waiting behind the barricades cleared the area within 20 minutes.

During the PGA Merchandise Conference last January, 70,000 attendees were able to easily ingress and egress the convention center without manual traffic control by police. In previous years, more than \$80,000 used to be spent on manual traffic control during each major event.

9. What are the traffic operation features that the System does not handle well (give 2 or 3 examples)?

?? *Special detector placement is required for short links less than 100 meters, otherwise a minimum fixed green time must be provided for those links.*

?? *Minimum cycle length must cover pedestrian clearance in all directions, resulting in unnecessary delays for side streets when vehicular & pedestrian volumes are low.*

?? *Phasing sequence is fixed in all times regardless of traffic patterns, resulting in less than optimum bandwidth along the arterial.*

10. In hind sight what would you have done differently during the implementation of this System?

Prior to the validation process:

?? *Construction inspectors should verify detector configuration.*

?? *System operators should test communication equipment.*

?? *County staff should be trained to design and validate the system for future expansions or troubleshooting.*

Adaptive Traffic Signals Control Systems QUESTIONS

Date: 7/10/2002

Name: Roger Plum (former city traffic signal operations engineer)

Agency: Short Elliott Hendrickson Inc. (for the City of Minneapolis, MN)

Phone Number: 651.765.2966

Adaptive System: SCOOT – # intersections in an arterial corridor

1. Initial comments about System.

The SCOOT implementation included 56 intersections under SCOOT control in a downtown grid network. Of these 56, only 6 could be considered to be an arterial with a definite major street and minor street.

2. If it is an add-on feature (SCOOT, RHODES) what is your primary traffic signal system?

Primary system: T2000C (central computerized traffic control system)

3. When was the System installed and operational (date)? When do you expect the System to be operational?

The SCOOT system was installed and operational as of October 1998.

4. What was the level of effort, by the System contractor, to make the System operational (days, months)?

The system contractor was responsible for determining the optimum location for the SCOOT system detection, while simultaneously training City staff in the determination of detector siting. This activity required approximately two weeks for the 135 detector locations. The system contractor also made software modifications to the existing system and integrated the SCOOT system, taking approximately 18 months for these efforts. Post-installation training was also provided as described in the answer to question 6.

5. What was the level of effort by City staff to make the System operational?

The primary efforts of the City to make the system operational were the addition of detection at 65 intersections and modifications to or replacement of controller cabinets at nearly all intersections. The detection (video) was installed by an electrical contractor in a single construction season (approximately 6 months). 65 intersections were detectorized, including the 56 intersections controlled by SCOOT and 9 additional "SCOOT boundary" intersections. The controller cabinet modifications and replacements were performed by the City over an 18-month

period – driven by the schedule of the software contractor. This time could have been shortened considerably if necessary.

6. What was the level of effort by City staff to understand the System operational and be able to use it on a day by day basis?

The City had two engineers working full-time side by side with (usually) one or (sometimes) two SCOOT experts provided by the SCOOT supplier for over two months immediately following installation of the system. The training included classroom-type (5%) introductory material, hands-on data preparation (15%), and hands-on field timing development and fine-tuning (80%). After the initial training and after the City had used the system for six months, the SCOOT supplier provided an additional two weeks of personnel time on-site to deal with any additional issues which had arisen and to review the work of the City personnel.

7. Where are the system detection loops located (distance from intersection)? What is the roadway design speed?

In general the system detection loops are located just over 300 feet upstream of the stop line, which for our grid system, placed them just downstream of the previous intersection. The roadway design speed is 30 mph. These distances represented a minimum recommended distance (7 seconds from detector to stop line), and longer distances were used wherever possible.

8. What are the traffic operation features that the System handles well (give 2 or 3 examples)?

Adjusts splits and offsets rapidly in response to changes in demand levels and in the source of those demands from upstream intersections.

Smoothly transitions from one cycle length to another, causing minimum disruption to traffic flows.

The system makes a large number of tools available to the user to accomplish the desired operation in a number of ways.

Automatically transfers intersections into or out of coordinated zones, depending on traffic activity levels and optimum cycle lengths.

9. What are the traffic operation features that the System does not handle well (give 2 or 3 examples)?

When there are two separate, approximately equal movements feeding a downstream link the system has difficulty assigning an offset to the intersection feeding the link.

The system has some difficulty dealing with short blocks. Since the recommended travel time between the detector and the stop line is 7 seconds, short blocks require special handling, using historical demands rather than real-time demands.

10. In hind sight what would you have done differently during the implementation of this System?

With the implementation, I cannot think of anything which I would have done differently. For the project as a whole, the selection of and monitoring of the evaluation consultant could have been better. Several mistakes were made by the consultant in gathering before-and-after data, rendering the project report relatively useless with regard to performance of the system. In-house evaluation of the system performance would have been better but was not an option due to limited City staff availability and the sources of project funding.

Adaptive Traffic Signals Control Systems QUESTIONS

Date: July 15, 2002
Name: Steve Kemp
Agency: City of Toronto, Canada
Phone Number: 416-397-5771

Adaptive System: UTC/SCOOT – UTC Version 21.4,
SCOOT Version 4.2 – Approx. 300 Intersections

1. Initial comments about System.

Can have significant on-street benefit (particularly during off-peak, peak period shoulders and special events. However, the benefit can only be realized if the system is properly setup and maintained.

2. If it is an add-on feature (SCOOT, RHODES) what is your primary traffic signal system?

SIEMENS UTC V21.4 is the base system that SCOOT runs on in Toronto. We have two other systems that do not run SCOOT Econolite ARIES (9 Intersections) and our own system that we refer to as MTSS (Main Traffic Signal System) which controls approximately 1600 traffic signals.

3. When was the System installed and operational (date)? When do you expect the System to be operational?

Original pilot project in 1992 (75 intersections). Major expansion in 1996 and annual program to expand further since then.

4. What was the level of effort, by the System contractor, to make the System operational (days, months)?

Several Months Effort.

5. What was the level of effort by City staff to make the System operational?

Several Months Effort + Continuous effort to maintain.

6. What was the level of effort by City staff to understand the System operational and be able to use it on a day by day basis?

Significant. Extensive training required. Years of hands on experience to become proficient with the system.

7. Where are the system detection loops located (distance from intersection)? What is the roadway design speed?

See attached detector drawing detector placement is determined based on a large number of factors. Road design speed varies from arterial to arterial. Detectors are placed a minimum of 7 seconds of travel time in advance of the stopline if possible.

8. What are the traffic operation features that the System handles well (give 2 or 3 examples)?

Signal timings during peak period shoulders, off peak, weekends, special events, adverse weather conditions.

9. What are the traffic operation features that the System does not handle well (give 2 or 3 examples)?

Protected/permissive left turn phasing where gaps in opposing flow is not predictable.

10. In hind sight what would you have done differently during the implementation of this System?

Wireless detection.

Do not change your “normal” traffic engineering strategies or overall approach to signal timing just because you are going with adaptive control. For example, set maximum cycle times and phase durations that you are comfortable with.

Adaptive Traffic Signals Control Systems QUESTIONS

Date: July 2002

Name: Traffic Control Operation Unit

Agency: Ministry of Transportation

Phone Number: 02-235-2676

Adaptive System: SCOOT – 300 intersections in an arterial corridor

1. Initial comments about System.

The Traffic control Operation Unit's main objectives are the administration, maintenance and operation of Santiago, Chile's traffic control system. This system controls and coordinates the operation of 1,800 traffic lights among 34 districts. The traffic control system operates in real time, and second after second, information is exchanged between the central computers (5 computer using an Ethernet network) and each traffic controller. To ensure its success, the system uses telephone networks, which are used only in a point-by-point network.

2. If it is an add-on feature (SCOOT, RHODES) what is your primary traffic signal system?

The system used is UTC Siemens, developed by Siemens Traffic Controls Ltd. Of the 1,800 existing traffic lights, 1,400 operate with fixed timing plans, 300 operate with SCOOT and the rest are fully actuated.

3. When was the System installed and operational (date)? When do you expect the System to be operational?

The project "Construction of an Area Traffic Control System" started in early 1994. From that date on, it was necessary to begin several projects that need to be done either before or simultaneously with the control systems installation. Among the most important projects was the standardization of traffic light installation, the replacement of most of the controllers, and the installation of the communication networks. We also had to complete all the traffic engineering analyses in order to define both the operation mode as well as the timing plan, that we intended to use in the different traffic lights networks. The system was installed in 1997 and was finished by 1998. In that year we had running the operation center, and the complementary systems. The complementary systems are a closed circuit TV network, variable message boards, a geographic information system, and a priority system for emergency vehicles.

4. What was the level of effort, by the System contractor, to make the System operational (days, months)?

The setup of 50 intersections took approximately 1 year while the full system's took 4 years

5. What was the level of effort by City staff to make the System operational?

We estimate that a new system user of the system will learn the basics in three months

6. What was the level of effort by City staff to understand the System operational and be able to use it on a day by day basis?

7. Where are the system detection loops located (distance from intersection)? What is the roadway design speed?

There are two types of loops according to their function: detection and occupancy, each located at different street locations.

Detection loops, needed for traffic light's, which operate under vehicle demand, are located 10 to 12 meters (32-39 feet) from the stop line.

The dynamic control loops needed to optimize timing plans (cycles, faces and offsets) according to vehicular flow is located at the beginning of the link. However its final location depends on the presence of bus stops, pavement quality, parking lots, mid block flow (gas stations, parking, small streets, schools, etc) link length, network configuration, distance to communication networks, etc

The designed speed of streets is not relevant to the placement of dynamic control loops. In order to have a loop up and running we have to calibrate some parameters in the data base. To calibrate, we have to incorporate link's data such as time at free flow speed from the loop to the stop line, time that the link needs to clear out if the link is full, loose time, gained time in yellow and link's capacity. These parameters plus the calibration itself imply the design speed of the street.

8. What are the traffic operation features that the System handles well (give 2 or 3 examples)?

The system has worked well since its implementation. It has demonstrated its monitoring capacity, failure detection, modification of the timing plan on line (a permanent change or temporal change as a response to an incident), generation of congestion level graphs, management of count station, archive and management of data base, holidays, contingency plans, etc. Making the network operates successfully despite the special aspects required by Santiago's network operation.

For example, the system has handled the modifications in operations well, specifically their reversibility of some of them according to the time of the day. Also, the system has permitted the implementation of contingency plans in response to special events such as reduction in the flow due to environmental emergencies and the opening of exclusive roads.

The dynamic control has operated well in networks with the following characteristics:

Networks with a low or medium percentage of transit, especially with small bus stop activities; networks with high flow variability during the day, especially at unexpected times of the day; networks close to the saturation point where small variation in the flow makes important effect in congestion; and intersections and arterials that operate well under dynamic control where there is sporadic variation

in the flow, for instance the result of incident, work on the road, vacation period, etc.

9. What are the traffic operation features that the System does not handle well (give 2 or 3 examples)?

As mentioned before, the system has complied with the necessary requirements needed to provide an efficient traffic management. Social economic evaluations show that the investment has been recovered in less than a year, which means that this is a project with high social revenue.

One aspect that can be improved is the fact that when an intersection is unhooked from the main system due to a failure on the phone line, there is no way to find out if the intersection is off. In any other case, the system can show when the intersection is off.

We have also evaluated networks with high presence of public transport (over 300 buses/hr) or with a high bus stop activity, the benefit of the dynamic control system are small respective to preset timing plans.

10. In hind sight what would you have done differently during the implementation of this System?

Under a long run perspective and without budget constraint, we would have studied more in depth better ways to communicate between the traffic light and the control center.

Another point, that already was redesigned, was the communication system for traffic light controllers. In the beginning we had a group of 8 controllers connected, so when we had a failure on the line we had all of them disconnected at once.

Since the number of traffic lights that were going off was too high, we redesigned the communication system, connecting just one traffic light independently that has since been more stable and without major inconveniences.

In regard to the dynamic control system, we have found from the last evaluations, that network configuration must be studied with more detail. We also have found that the dynamic control loops must be built downstream from bus stops, and if necessary, they must be moved. This is an important subject in Santiago due to the high presence of public transport.

Adaptive Traffic Signals Control Systems QUESTIONS

Date: July 10, 2002

Name: Gary Piotrowicz

Agency: Road Commission for Oakland County, Michigan

Phone Number: 248 858-7250

Adaptive System: SCATS – 575 total intersections

- 1. Initial comments about System.**
- 2. If it is an add-on feature (SCOOT, RHODES) what is your primary traffic signal system?**
Not applicable.
- 3. When was the System installed and operational (date)? When do you expect the System to be operational?**
June 1992.
- 4. What was the level of effort, by the System contractor, to make the System operational (days, months)?**
One year for first 28 intersections.
- 5. What was the level of effort by City staff to make the System operational?**
It took a great deal of coordination and effort across several divisions including, signal engineering, traffic engineering, and signal maintenance.
- 6. What was the level of effort by City staff to understand the System operational and be able to use it on a day by day basis?**
SCATS is a high level signal system. The complexity is directly proportional to its ability to move traffic. As a result, the system take many years to learn, and even more to become truly proficient. New Windows based software has made training easier, but the underlying philosophy and logic is still complex. SCATS is very powerful and an excellent system, it just takes time to fully understand.
- 7. Where are the system detection loops located (distance from intersection)? What is the roadway design speed?**

About 80% of our detection zones are Autoscope, the rest are loops. They are all located at the stop bar.

8. What are the traffic operation features that the System handles well (give 2 or 3 examples)?

Handles left turns and variable volume levels very well. Also good at responding to congestion at unusual times.

9. What are the traffic operation features that the System does not handle well (give 2 or 3 examples)?

Progression is the least “smart”. Tables need to be set up by the engineer and the system picks a value based on conditions. If the tables are wrong, the progression will be poor.

10. In hind sight what would you have done differently during the implementation of this System?

We use leased phone lines. We should have gone with fiber or other medium that would have allowed us to easily install CCTV and bring back our Autoscope images. We could then have programmed the Autoscopes from the TOC and been able to respond quicker to detector issues. We also used the Australian phasing set-up. We have now switched to the standard NEMA with even numbers for thru movements and odd number load switches for left turns. We also should have gone with lamp monitoring. This was an extra device and relatively expensive but would have been very beneficial.

Adaptive Traffic Signals Control Systems QUESTIONS

Date: August 6, 2001

Name: Linda Taylor

Agency: Minnesota DOT

Phone Number: 651-634-2126

Adaptive System: SCATS – I-494 Freeway Corridor with 71 signalized intersections and ramp metering. Ramp metering has been suspended due to study being performed.

1. Initial comments about System.

SCATS was originally chosen due to its ramp meter component, its complete signal system package and good vendor support. The vendor was very willing to work with the State. This was an FHWA Operational Test. The other Adaptive System in the area (SCOOT) was an add-on component to an existing signal system. MinnDOT did not see same level of support from SCOOT vendor.

Over time Neil Gross with TransCore has provided good support and the dial up service has been very effective at resolving problems.

2. If it is an add-on feature (SCOOT, RHODES) what is your primary traffic signal system?

SCATS is a fully contained system. MinnDOT will be looking at purchasing Eagle or Econolite intersection controller for future use with the System. Delta (Australian) controllers are no longer available. These NEMA controllers will be a big improvement for the maintenance staff. MinnDOT area technicians are not comfortable with the 170E controllers.

3. When was the System installed and operational (date)? When do you expect the System to be operational?

This freeway corridor project was an FHWA operational test which started implementation in early 1995. The full system became operation in 1998.

4. What was the level of effort, by the System contractor, to make the System operational (days, months)?

Need to prepare the vendor with good geometric data and turning movement data. For SCATS, a turnkey operation should take a couple of months. The training of staff requires a number of follow up visits.

5. What was the level of effort by City staff to make the System operational?

Significant effort in the beginning. This operational system test had a lot of communication equipment issues in the beginning. Between construction problems which cut communication lines, the use of multiply communication mediums and the first use of the system by multiple agencies created a significant

effort for staff to overcome and make the system operational. There were also system software upgrades. This was a beta test site for the communications effort.

6. What was the level of effort by City staff to understand the System operational and be able to use it on a day by day basis?

At this point the effort is not significant. MinnDOT uses part time college students to assist with the system work effort. These interns are given three days training and then left on their own to work with the system. The level of effort is to learn and use SCATS is comparable with any other closed loop system. Obviously the more you use it the more proficient you become.

The new user GUI interface is a huge improvement over the previous system interface. This contributes greatly to the intern's ability to learn and use the system

7. Where are the system detection loops located (distance from intersection)? What is the roadway design speed?

MinnDOT install 6x15 foot loops at the stop bar or close to it. Because of winter snow, technicians go out and monitor where motorists stop and install the loops accordingly. MinnDOT retains the back/advance loops at the intersection in case emergency situations require that technicians swap controllers and install a NEMA controller to keep the intersection operational.

8. What are the traffic operation features that the System handles well (give 2 or 3 examples)?

1) Masterlink has nice tools which allows the system to be monitored and the new GUI presents the information in a useful format. 2) SCATS has a lot of capabilities which can be tapped for special conditions. 3) The ability of the SCATS to respond to the actual field conditions. This freeway corridor has a lot of commercial and retail development which has traffic patterns changing all of the time.

9. What are the traffic operation features that the System does not handle well (give 2 or 3 examples)?

1) Generation of the controller personalities is kind of a pain. It could be made more user friendly. 2) Some of the features in the old system are not fully implemented in the new GUI system. This causes new users and casual users a problem. 3) The Delta 3 (Australian) controller interface is not user friendly. Technician are used to NEMA controllers.

10. In hind sight what would you have done differently during the implementation of this System?

Would have worked on smaller implementation chunks. Went from 15 intersections to 68 intersections in one jump. It is better to work incrementally. Get a reasonable number up and operational which is based on staff availability and commitments then movement to the next reasonable sized chunk.

Adaptive Traffic Signals Control Systems QUESTIONS

Date: August 3, 2001

Name: Bob Hunt

Agency: City of Tucson

Phone Number: 520-791-4259

Adaptive System: RHODES ----- Give name of corridor and number of signals

1. Initial comments about System.

(from an email) Don, you are the 2nd person asking for information on RHODES. Unfortunately, I don't have a lot of information for you. We've been working with the University providing them equipment and a test bed for the development but to date we have no running RHODES controllers on Tucson streets.

As a result we don't actually have any hands on RHODES experience. I know they are finalizing some of the peer to peer communication stuff and we are hoping to have RHODES on the street in the near future.

Other than that about all I can tell you is that simulation stuff that we've seen does show a significant increase in traffic throughput with RHODES. I know it will probably be to late for you, but get back with me towards the end of this year, 1st of next and I should have more information for you.

Just as an FYI on your loop questions, we have Autoscope at all of the intersections where we plan to test RHODES. Again, at this time we don't know how well these will work for what RHODES needs.

- 2. If it is an add-on feature (SCOOT, RHODES) what is your primary traffic signal system?**
- 3. When was the System installed and operational (date)? When do you expect the System to be operational?**
- 4. What was the level of effort, by the System contractor, to make the System operational (days, months)?**
- 5. What was the level of effort by City staff to make the System operational?**
- 6. What was the level of effort by City staff to understand the System operational and be able to use it on a day by day basis?**

- 7. Where are the system detection loops located (distance from intersection)? What is the roadway design speed?**
- 8. What are the traffic operation features that the System handles well (give 2 or 3 examples)?**
- 9. What are the traffic operation features that the System does not handle well (give 2 or 3 examples)?**
- 10. In hind sight what would you have done differently during the implementation of this System?**

Adaptive Traffic Signals Control Systems QUESTIONS

Date: Monday July 30, 2001
Name: Jim Decker
Agency: City of Tempe
Phone Number: 480-350-8320

Adaptive System: RHODES – Diamond intersection at US 60 and Rural Road.
One Eagle 2070 controller.

1. Initial comments –

Jim shared the following comments. RHODES is a research project. Jim helped develop the RHODES system. RHODES has not been deployed anywhere at this time. The RHODES project in Tempe is a diamond interchange operated by one controller. He chose to have no skip phases for driver expectancy. The setup has 16 system detectors used from the City's Computran traffic signal system. The 16 system detectors give an upstream advance planning time of 45 seconds. Eight Autoscope cameras were installed for stop bar/queue detection. The City initially installed the System and it operated on average as well as the time of day plans. City then made operational enhancements and the RHODES performance improved. City plans to perform an evaluation test on July 31st and August 1st.

2. If it is an add-on feature (SCOOT, RHODES) what is your primary traffic signal system?

RHODES uses the Computran system for its system detection information. An interface program was written to collect the detector data from the Computran System and pass it to an Icons System which then forwards the detection information to the 2070 at the intersection. The System does not need Icons to function, it is merely an interface.

3. When was the System installed and operational (date)? When do you expect the System to be operational?

System installed December 2000. System is still a research project. Expect to install a corridor test next spring.

4. What was the level of effort, by the System contractor, to make the System operational (days, months)?

Getting the 2070 to work in a TS2 cabinet took the greatest amount of time. A lot longer than expected. To get RHODES operating at the intersection took from 2 weeks to a one month effort for the System contractor.

5. What was the level of effort by City staff to make the System operational?

Due to the fact that this implementation was a joint research effort with the City considerable staff time was needed to make the intersection operational.

6. What was the level of effort by City staff to understand the System operational and be able to use it on a day by day basis?

For a new installation by another agency it would probably take a couple of months to learn how to operate RHODES. This is on par with the implementation of any new System, Series 2000 etc.

7. Where are the system detection loops located (distance from intersection)? What is the roadway design speed?

Sixteen system detectors are located upstream from the test intersection, spaced at a distance up to 45 seconds at free flow speed. These are primarily existing system detectors from the City's Computran System. New system loops were placed on the freeway off-ramps.

Eight Autoscope cameras were installed to handle queue detection at the stop bar. The size of the detection zone emulates a 6 x 50 foot detection zone.

8. What are the traffic operation features that the System handles well (give 2 or 3 examples)?

1) Responds well to the varying traffic flow on a cycle by cycle basis with cycle length changing each time. 2) Responds well to incidents or construction where the capacity of the intersection is all of a sudden reduced.

9. What are the traffic operation features that the System does not handle well (give 2 or 3 examples)?

Jim expressed that he did not have enough experience to know what the System does not handle well. Jim expressed that current RHODES system 1) does not have the ability to figure upstream vehicle speed and density and 2) time to the stop bar from a system detector is calculated not measured.

10. In hind sight what would you have done differently during the implementation of this System?

Would have worked out hardware problems ahead of time. Jim had no idea how difficult it would be to get a 2070 controller working in a TS2 cabinet. There was also a lot of effort on interface work between the Computran System detectors, Icons, 2070 controller, TS2 cabinet and the RHODES software which operates in the 2070 controller.

Adaptive Traffic Signals Control Systems QUESTIONS

Date: July 19, 2002
Name: Mike De Angelo, Tim Bourne
Agency: NJDOT
Phone Number: Mike (609) 530-2608, Tim (201) 797-7538
Adaptive System: OPAC – 12 intersections in an arterial corridor

1. Initial comments about System.

When running, it is a very efficient system. However, the system was difficult to maintain due to the complexity of the hardware components and the physical infrastructure.

2. If it is an add-on feature (SCOOT, RHODES) what is your primary traffic signal system?

The system was designed to operate traffic responsive under OPAC with a Multisonics “OSAM” closed loop system as backup.

3. When was the System installed and operational (date)? When do you expect the System to be operational?

March 1996. However, the fiber optic backbone and system detectors have not been satisfactorily maintained so the system is currently not operational. I believe that there was also a Y2K issue with the 170 controllers that also created maintenance headaches.

4. What was the level of effort, by the System contractor, to make the System operational (days, months)?

There was a lot of difficulty mainly because this was our first attempt to interconnect a system using fiber optic cable and the software for the system was being developed concurrent with the installation of the hardware.

5. What was the level of effort by City staff to make the System operational?

The local City staff was not involved. However, State staff spent numerous hours troubleshooting and configuring the system hardware.

6. What was the level of effort by City staff to understand the System operational and be able to use it on a day by day basis?

The local City staff was not involved. However, State staff were trained by the software developer on system operation and control. A lot of time was also spent after training using the system and becoming familiar with all of its capabilities and report generation characteristics.

7. Where are the system detection loops located (distance from intersection)? What is the roadway design speed?

It varied due to the distance between intersections. Because the software recognized speed as well as occupancy, every effort was made to make sure that the loops were located such that the vehicles would be traveling at normal speeds so that platoons of vehicles could be recognized and processed by the software. On average, approximately 50 yards from the intersection.

8. What are the traffic operation features that the System handles well (give 2 or 3 examples)?

1. The ease of which the parameters of the software could be changed.
2. It did decrease travel time on the corridor but due to the geometric constraints of the corridor, this decrease was not all that noticeable.

9. What are the traffic operation features that the System does not handle well (give 2 or 3 examples)?

1. Due to the geometric constraints of the corridor and the traffic congestion that is present, it was difficult to analyze the overall performance of the system.
2. Due to the amount of fiber optic cable and system detectors installed, it was very difficult to maintain.

10. In hind sight what would you have done differently during the implementation of this System?

1. Utilize system hardware that has been proven in the field under the harsh environmental conditions that exist.
2. Fully bench test the system hardware and software before implementation in the field.
3. Set up a better maintenance program so that the system can be adequately maintained.