UTAH DEPARTMENT OF TRANSPORTATION

WORLD CLASS
TRAFFIC SIGNAL MAINTENANCE
& OPERATIONS

QUALITY IMPROVEMENT TEAM
Final Report

July 2011

Disclaimer:

The contents of this report reflect the view of the Quality Improvement Team (QIT). The QIT is responsible for the information and accuracy of the data presented herein. The contents do not necessarily reflect the official views or policies of the Utah Department of Transportation.

Future modifications to the UDOT signal program may reflect the recommendations in this final report; however, further refinement of the ideas in this final report is likely.

This report is technical in nature. It is assumed that the reader has a basic knowledge of traffic signal maintenance and traffic signal timing.

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Executive Summary

UDOT Executive Director John Njord assigned a Quality Improvement Team (QIT) to make recommendations that will result in UDOT providing "**world class traffic signal maintenance and operations**." The QIT evaluated existing operations, national best practices, and NCHRP recommendations and found that in general, UDOT needs to move from a reactive to a proactive stance in both signal maintenance and signal timing and coordination. The QIT identified barriers and makes 20 recommendations to elevate UDOT to world class signal maintenance and operations.

7 BARRIERS TO WORLD CLASS

The current reactive stance on signal maintenance and operations is the result of inadequate resources and management structure to move beyond focusing on the most pressing concerns. In this environment, important but less urgent tasks such as implementing an asset management system, automated signal detector health monitoring, automated performance measurement, and regular retiming of corridors are inadequately addressed or overlooked altogether.

The QIT identified 7 barriers to world class signal maintenance and operations:

Barrier 1: Maintenance of Signal Equipment. UDOT is not proactive in maintaining signal equipment. A 2007 signal report card issued UDOT a failing grade for signal maintenance. While current signal maintenance is improved, there is room for improvement. An estimated 25% or more of signal detection is not functional; statewide LED signal indications are near the end of their lifespan; and a good portion of other signal infrastructure (conduit, cabinets, poles, mast arms, wiring) is nearing the end of its lifespan.

Up until 2007, UDOT budgeted about $1.0 million per year ($1,000 per signal) for signal maintenance. After the 2007 report card, this was increased to $3.325 million per year ($2,950 per signal). This partially explains UDOT's backlog of signal maintenance. Research suggests that signal maintenance funding should be $4,500 per signal per year. UDOT analysis recommends funding of $4.855 million per year, or $4,300 per signal.

QIT Recommendation: Transition from reactive to proactive signal maintenance by increasing signal maintenance funding from $3.325 million to $4.855 million per year.

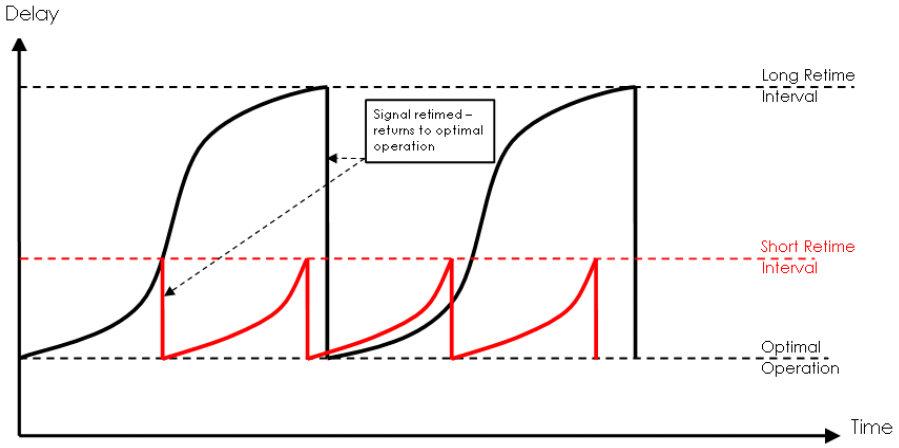
Barrier 2: Staffing. National best practices show that UDOT is appropriately staffed in technicians but has about one third of the recommended engineering staff to operate 1,125 statewide traffic signals. To achieve world class, UDOT should provide sufficient staff to manage, maintain, and operate the system proactively and efficiently. This can be accomplished by adding 8 new engineering positions focused on maintenance and operations. Four positions are in the regions to establish management and planning capability for signal maintenance, coordination with construction, and to develop region expertise in signal timing and coordination. Four positions are in the TOC to provide the resource to manage and engineer statewide signal timing and coordination plans, and to support the regions with technical expertise. This staff could be provided by consultants.

QIT Recommendation: Add 8 new FTEs (or the consultant equivalent) to the areas of signal maintenance and signal operations; 4 in the regions and 4 at the TOC. Increase signal operations funding from $225,000 to $720,000 per year.

Barrier 3: Expertise in the Regions. The Regions lack the expertise to fully participate with the TOC in operating the signal system. This leads to miscommunication and pursuit of differing goals.

QIT Recommendation: Develop expertise in the Region Signal Engineers through constant interaction with the Signal Operations Engineers at the TOC.

Barrier 4: Performance Measurement. UDOT should have a better understanding of both the health of the signal system, and the quality of signal operations. A higher level understanding requires a management structure, an asset management system, and real-time monitoring of the quality of signal operations. Understanding our system will facilitate strategic action. For example, consider the benefit of strategically updating signal timing and coordination:



QIT Recommendation: Implement real-time monitoring of system health and quality of operations. At a minimum, retime all signals on a 30-month cycle.

Barrier 5: Policies and Procedures. Expectations for signal operations must be established through policy. We have little in policy to require that vehicle detection at signals remain functional, and that communications to the TOC be maintained. This is necessary during construction, third party, and permit projects. Any interruptions to communication or detection must be addressed in a timely fashion. UDOT does not have policies that address operational support for special events.

QIT Recommendation: Require that communications and signal detection be maintained during projects. Develop a guideline to determine the threshold for special events to be supported by the TOC.

Barrier 6: Maintenance Planning. UDOT lacks the staffing necessary to plan strategically for signal system maintenance, and lacks an asset management system for signal equipment. Without these two key components, only the most pressing maintenance needs get addressed, and often only at the technician level. This is a reactive, rather than a proactive approach.

QIT Recommendation: Add a Signal Engineer in each Region to strategically plan for signal maintenance and implement an asset management system for signals.

Barrier 7: Roles and Responsibilities. UDOT's traffic signal program involves 7 UDOT groups. Current roles and responsibilities are not formalized, resulting in omissions and duplications. Clear expectations are needed to ensure the most efficient program.

QIT Recommendation: Formalize the roles and responsibilities as shown below.

UDOT Signal Program – Roles and Responsibilities

Role	Responsibility				
	Budgeting	**Signal Maintenance**	**Asset Management**	**Signal Operations**	**Warranting & Construction**
Lead	CM	Regions	Regions	TM	T&S
Support	TM	TM T&S	TM	Regions	Regions
Consultant Potential	None	Low	High	High	Medium

Notes:
'CM' = Central Maintenance Division
'TM' = Traffic Management Division
'T&S' = Traffic and Safety Division

OPTIONS FOR IMPLEMENTATION

The QIT was also asked to evaluate options for achieving implementing the QIT recommendations. Three options are presented. Each could be further customized.

Option #1: World Class through UDOT Full Time Equivalent (FTE) Positions
This option provides world class signal maintenance and operations by adding UDOT FTEs and increasing maintenance funding as described on page E-1 under **Staffing** and **Maintaining our Signal Equipment**. In summary, Option 1:

- Adds a total of 8 new FTEs; 4 in the Regions, 4 at the TOC.
- Increases the statewide signal maintenance and operations budget by $2.025 million to $5.575 million.

Option #2: World Class through Consultants
This option is designed to produce the same results as Option #1, except that added FTEs are minimized through the use of consultants. In summary, Option 2:

- Adds a total of 2 new FTEs, one in Region 1 and one in Region 3.
- Temporarily uses 2 FTEs at the TOC to fill new Engineer Manager (EM) II Signal Operations Engineer and EM I Signal Timing Engineer positions. These 2 positions will be returned to Leadership as soon as vacancies at the TOC allow. The intended result is for the 3 existing positions at the TOC to transition from one EM I and two CE IIIs to one EM II and two EM Is. This transition may take time.
- Increases the statewide signal maintenance and operations budget by $2.975 million to $6.525 million. The additional $0.950 million versus Option 1 accounts for the 6 FTEs that are replaced by consultants.

Option #3: Incremental steps to World Class

This option offers a phased management plan to minimize costs while incrementally moving UDOT toward world class signal maintenance and operations. The basic philosophy of the incremental plan is that signal maintenance must come first. Signal timing is best done on a functioning system. Once the serious maintenance issues are addressed, then funding should shift to address both signal maintenance and signal timing and coordination.

Phase 1: Focus on Signal Maintenance. Phase 1 will prioritize signal maintenance over signal operations for a period of 3-5 years. During this time, resources are added to signal maintenance while resources for signal operations remain at current levels. Phase 1 will:

- Add 2 new EM I Signal Engineer positions, one each for Region 1 and 3.
- Add the equivalent of ½ EM I Signal Engineer in Region 4 through consultants.
- Create a new EM II Signal Operations position at the TOC. This position will be returned to Leadership as soon as vacancies at the TOC allow.
- Prioritize available funds (up to QIT recommended limits) on signal maintenance.
- Maintain current funding at the TOC for signal timing and coordination.

Phase 2: Balanced focus on Maintenance and Signal Timing. As the quality of signal maintenance improves, in roughly 3-5 years resources should be added to fully implement Option 1 or 2, resulting in a balanced approach to signal maintenance and signal operation.

Comparison of Options

Budget Summary for Options

	Current	Option 1	Option 2	Option 3 (Phase 1)
Signal Maintenance	$ 3.325 M	$ 4.855 M	$ 4.855 M	$ 4.855 M
Signal Operations – Consultants	$ 0.225 M	$ 0.570 M	$ 1.520 M	$ 0.325 M
Signal Operations – Equipment	$ 0	$ 0.150 M	$ 0.150 M	$ 0.150 M
Total	$ 3.550 M	$ 5.575 M	$ 6.525 M	$ 5.330 M
UDOT FTEs	4	12	6	6

I. Introduction

Traffic demands in Utah continue to grow. Despite Utah's considerable investment in transportation infrastructure, it is impossible to add capacity at a rate that matches growth. Given this reality it is imperative for UDOT to optimize traffic flow using techniques that do not involve adding lane-miles, such as traffic signal coordination and travel demand management. In response, John Njord has asked the Traffic Management Division to lead a Quality Improvement Team (QIT) to make recommendations that will result in UDOT providing "**world class traffic signal maintenance and operations**." This report documents the efforts of the QIT.

The goal of this QIT is to provide recommendations to UDOT Senior Leaders on two topics that are integral to effective traffic signal operations:

1. Improving traffic signal maintenance by the Regions through funding and technical standards.
2. Improving statewide traffic signal operations through signal timing and coordination.

The QIT makes 20 recommendations that, in the opinion of the QIT, would elevate traffic signal operations in Utah to world class.

II. World Class Traffic Signal Operations

Inefficient signal operation causes unnecessary delay, resulting in wasted time, increased fuel consumption, and increased vehicle emissions. For individuals this means frustration and a lack of confidence in UDOT. The traveling public expects UDOT to operate traffic signals safely and efficiently. They expect this of every signal in the system, and they expect it every time they drive, bike, or walk through a signalized intersection.

From the public's perspective, the following four key objectives must be met to achieve **world class traffic signal operations**:

1. Safe signal operations.
2. Efficient and optimized signal timing and coordination.
3. Consistency in the quality of operation.
4. Comprehensiveness in coverage.

What the public perspective does not account for is maintenance. Inefficient signal operations can result from ineffective signal timing and coordination, poor traffic signal maintenance, or a combination of each. Neither is capable of compensating for the inadequacies of the other without sacrificing efficiency. If detection is not working, the ability to have the signal respond to traffic demands is lost. This makes it appear as though the signal timing and coordination is lacking. On the other hand, a traffic signal that is 100% functional will become inefficient if the signal timing is been neglected. A commitment to world class signal operations is a simultaneous commitment to **world class traffic signal maintenance** and **world class signal timing and coordination**.

UTAH TRAFFIC SIGNAL REPORT CARD

In 2007, the National Transportation Operations Coalition produced a National Report Card Survey on Traffic Signals. The purpose was to:

- Assess current state of signal operations.
- Bring attention to traffic signal operations.
- Create awareness of benefits of good operations.
- Make the case for additional funding.

The national grade was 62% (D-), while UDOT received a 72% (C-). Six areas were evaluated. They are:

Category	National Grade	UDOT Grade
Proactive Management	58%	92%
Coordinated Systems	61%	87%
Individual Intersections	72%	69%
Detection	53%	67%
Maintenance	67%	45%
Overall	62%	72%

Notably, UDOT's lowest scores were for maintenance and detection, and the maintenance score was considerably lower than the national average. In response UDOT has increased

funding in the last three years for maintenance and detection which has improved the situation.

BENEFIT OF SIGNAL TIMING

Signal timing and coordination has a positive impact on delay. Signal timing deteriorates over time, requiring that signal timing be periodically "reset" to optimal operation. The relationship between the deterioration of traffic signal timing over time and the subsequent driver delay is shown in Figure 1.

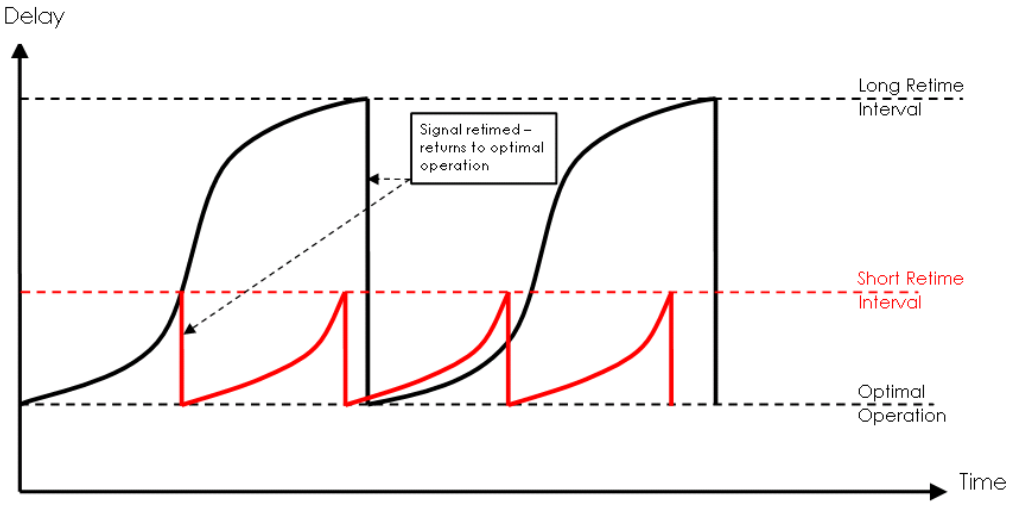


Figure 1. Signal Timing Deterioration vs. Time

The total delay experienced by users is the area under the delay curve. The area under the curve is greatly reduced by "resetting" the delay to optimal operation more frequently, as shown in red.

BEST PRACTICES FOR WORLD CLASS TRAFFIC SIGNAL OPERATIONS

In order to achieve the four objectives noted above, the focus must be on maintaining the traffic signal infrastructure, and on optimizing the operation of that infrastructure. A number of recent research efforts undertaken by ITE, AASHTO, FHWA, and the National Transportation Operations Coalition have addressed the topic. In March 2009 the Federal Highway Administration published the guidebook, "Traffic Signal Operations and Maintenance Staffing Guidelines." This Guide is a synthesis of previous work performed by the organizations mentioned above. The stated audience for the guide is, "…agency managers, practitioners and personnel seeking to gain an understanding of the resource requirements to effectively and efficiently operate and maintain traffic signals." This guide is an excellent source to understand the state of the practice and recommended best practices.

In addition to this national research, UDOT staff has a high level of expertise and understanding on the subject of traffic signal operations. The QIT synthesized the national research with local UDOT knowledge and expertise to identify the following best practices

considered by the QIT to be consistent with world class signal operations. These best practices are organized into the following five categories:

1. Staffing.
2. Signal Maintenance.
3. Signal Operations.
4. Policy & Process.
5. Management & Planning.

The remainder of Section II presents the QIT's summary of world class signal operations characteristics based on national research and Utah experience. An evaluation of UDOT's current performance against these best practices is presented in Section III.

Best Practices: Staffing

- Provide sufficient staff to maintain and operate the traffic signal system:
  - Provide one traffic engineer for every 75 to 100 signals.
  - Provide one signal technician for every 40 to 50 signals.
  - Research indicates that in each case the high end of the range is applicable to UDOT due to economy of scale.
- Provide an on-going technical training program for maintenance and signal operations personnel (both technicians and engineers).
- Establish minimum staff qualifications for signal technicians and engineers.
- Develop de-centralized signal timing and coordination expertise. This would facilitate a higher level of ownership for signal timing in the Regions.
- Actively monitor and manage signal operations. This requires comprehensive weekday and Saturday coverage of the TOC Signal Desk.
- Provide the in-house expertise necessary for successful implementation of special innovative projects such as CFIs, DDIs and flex lanes. These projects require considerable experience and the ability to be hands-on with the systems (typical consultants do not have this expertise).

Best Practices: Signal Maintenance

- Maintain operation of 90-95 percent of all detection in the signal system at any given time, including during construction.
- Commit on-going funding to repair, replace, or upgrade signal controllers, detectors and other signal hardware.
- Allocate 70% of maintenance resources (funding and staff) to proactive maintenance. On a well-functioning system only 30% should be for reactive maintenance.
- Utilize performance measurement of signal maintenance tied to clear goals and objectives. Potential performance measures include:
  - % of functional detection. Downtime measured in device-days.
  - % of preventative maintenance vs. reactive maintenance.
  - Response time to address signal malfunctions.
- Assess the condition of traffic signal control equipment annually (at a minimum) to verify that:
  - Detectors are working properly.

    - Signal controller timings are calculated and entered into the controller correctly.
    - Signal displays are appropriate and operational, including aging LED displays.
    - Routine preventative maintenance is performed, including conflict monitor testing.
- Define the time frame for responding to malfunctions and the criteria for prioritizing among multiple problems.

Best Practices: Signal Operations

- Use traffic signal control software to manage signal operations.
- Perform signal re-timing evaluations every 30 to 36 months at a minimum – until the system is capable of automated, real-time monitoring.
- Implement automated, real-time monitoring of system health and performance. The system identifies underperforming operations and malfunctions, rather than relying on a review cycle. This methodology is being developed in a pooled-fund study through Indiana DOT.
- Utilize performance measurement of signal operations tied to clear goals and objectives. Potential performance measures include:
    - % of vehicles arriving on green.
    - % of unused green time.
    - Volume / capacity ratio.
    - Split saturation (failure of high-volume movements).
    - Corridor travel times.
    - Total traffic volume served.
- Provide quality signal timing by actively managing all closures and restrictions that impact freeway, arterial, and ramp capacity during:
    - Construction, maintenance, and permit projects.
    - Traffic incidents, civic events, and weather events.
- Use adaptive traffic signal systems that react to changes in traffic volumes in real-time.

Best Practices: Policy & Process

- Require that:
    - Communication to traffic signals is maintained at all times, including during construction, maintenance, and permit projects.
    - Signal detection is maintained at existing traffic signals at all times, including during construction, maintenance, and permit projects.
    - Liquidated damages are assessed on projects for loss of communications and loss of vehicle/pedestrian detection.
    - Traffic signal detection is operational when a new signal is turned on. Signals in construction projects are frequently turned on running fixed-time (very inefficient), and configuration of signal detection is often left to the end of the project, sometimes months after a signal is turned on. On the other hand, fully functional signal systems in a workzone can decrease delays by as much as 20-30%, minimizing inconvenience to the public.

- Include as part of a project scope of work the timely replacement or repair of detectors that are destroyed or disabled by maintenance or permitted activities. Provide temporary detection for use during construction that can be replaced by the final solution. This temporary detection could be state-furnished from a pool that moves from project to project.
- Include signal timing parameters and coordination timings in MOT plans, and plan sets for construction.
- Establish a clear definition of roles and responsibilities between projects, the Regions and Central Operations.
- Include reviews from the signal operations and signal maintenance perspectives in the traffic signal design process.
- Establish goals and objectives for incident and special event management. Relevant questions include:
    - How does UDOT decide which events to manage?
    - Who decides?
    - What is the funding source?

Best Practices: Management & Planning

- Create and maintain a Traffic Signal Management Plan. The Plan should include a mission statement, strategic plan for maintenance and operations, objectives and measures, and periodic collection and review of performance data.
- Use an asset management system to track equipment failures and to facilitate proactive maintenance. The system should have GIS capability to display data geographically.
- Maintain an inventory of all pertinent traffic signal equipment, including an inventory of the configuration of each traffic signal.
- Manage signal timing parameters to provide consistent, reproducible signal timing throughout the state (for example, yellow and red clearance times).
- Coordinate with partner agencies (Cities and Counties) to provide consistent operation of signals across jurisdictions.
- Maintain a high level of communication and coordination between the cities, counties, Regions and Central Operations.
- Make optimal use of existing funding for signal operations. Ensure that funds are addressing the highest priority needs.
- Plan for long-term maintenance issues such as LED replacement, installation of new countdown pedestrian signals, and upgrades of TS-1 cabinets to TS-2.
- Develop a plan to implement low-cost signal improvements that increase safety, capacity, and efficiency. These improvements include flashing yellow arrows and right turn overlaps. These improvements can improve operations for specific movements by as much as 50-60%.

III. World Class vs. Current UDOT Practice

A comparison of the best practices of world class traffic signal maintenance and operations and current UDOT practice is shown in Table 1. The following is used to grade UDOT performance relative to the best practice:

- Green = UDOT practice meets this best practice.
- Yellow = UDOT practice needs improvement for this best practice.
- Red = UDOT practice is inadequate for this best practice.

Table 1: Best Practice for World Class vs. Current UDOT Practice

World Class Best Practice	UDOT Practice	Grade
STAFFING		
1 signal engineer for every 100 signals	1 signal engineer for every 280 signals (1,125 signals / 4 engineers)	
1 signal technician for every 50 signals	1 signal technician for every 55 signals (1,125 signals / 20 technicians)	
On-going training program for signal technicians	Electronic Technicians training program, incl. IMSA certification.	
On-going training program for signal engineers	No program for engineers.	
Minimum qualifications for all signal staff (engineers and technicians)	Qualifications exist, but are not specific to signal operations	
Signal timing and coordination expertise in the Regions	Techs focus on controller parameters, not coordination. Engineers don't have expertise.	
Actively manage signal operations at the TOC Signal Desk (weekday and Saturday comprehensive coverage)	TOC Signal Desk coverage on weekdays (30 hrs/wk consultant, suppl. by 40 hrs CORE, and 10 hrs TOC). CORE ends in Dec 2012.	
Support the implementation of innovative projects.	Past and current projects include 6 CFIs, 3 DDIs, 1 Thru-turn, 12+ SPUIs, and flex lanes	
SIGNAL MAINTENANCE		
90 – 95% of signal detection operational	Approximately 75% of detection operational (estimated).	
On-going funding for proactive signal equipment maintenance	$2M for signal detection; $375k for signal controllers; majority of work is reactive.	
70% of maintenance resource and activity on proactive maintenance	25% or less of current maintenance resource and activity is proactive	
Performance measurement of signal maintenance	None	
Proactive routine maintenance program with documentation	Does not occur consistently statewide; Regions' efforts are informal; no doc.	
Annual conflict monitor testing with documentation	Regions 2, 3, and 4 have a regular program; documentation could be improved	
Timeframe to resolve malfunctions	No formal timeframes have been established	

Table 1: Best Practice for World Class vs. Current UDOT Practice		
World Class Best Practice	**UDOT Practice**	**Grade**
SIGNAL OPERATIONS		
Use of traffic signal control software to manage signal operations	UDOT uses Siemens i2 software, as do all of our partner agencies.	
Re-time signals every 30 to 36 months	Not possible with current resources. Efforts focus on obvious problems.	
Automated, real-time monitoring of signal system health and performance	None	
Performance measurement of signal operations	None	
Quality signal timing during construction	Not required or common. Large projects sometimes hire timing consultants.	
Quality signal timing during incidents, civic events, and weather events	Limited. There are no stated goals, or resources identified to support those goals.	
Implementation of adaptive signal operations	2 demonstration projects: SCATS in Park City; ACS Lite in Heber	
POLICY & PROCESS		
Communication to signals maintained at all times, incl. during construction	Not required	
Detection at traffic signals maintained at all times, incl. during construction	Not required	
Signal detection to be operational as designed when a signal is turned on	Not required	
Permit or third-party projects repair or replace damaged detection	Not required	
Signal timing parameters and coordination timings in plan sets	Not required	
Clear definition of roles and responsibilities for Regions & Central	Gaps and duplication in roles and responsibilities exist.	
Signal design reviews by signal operations group	Not required	
Defined goals and procedures for incident and event management.	Incident/Event response is based on availability of resources and staff interest	
MANAGEMENT & PLANNING		
Traffic Signal Management Plan	None	
Asset management for signal system	None	
Inventory of signal system equipment and configuration	Region 1 initiated this task, Regions 2, 3, and 4 are implementing. TOC is supporting.	
Management of signal timing parameters	The TOC is pushing this statewide	

Table 1: Best Practice for World Class vs. Current UDOT Practice		
World Class Best Practice	**UDOT Practice**	**Grade**
Coordination with partner agencies	This is occurring and is productive.	
High level communication between Regions and Central on timing issues	This area is improving, but could be much better.	
Optimal use of signal maintenance and signal operations funding	We believe we are doing a good job, but have limited ability to verify at this time.	
Plan to address long-term maintenance issues	None	
Plan to implement low-cost signal improvements for safety & operations	None	

UDOT BARRIERS TO WORLD CLASS

This evaluation reveals that UDOT has room for improvement to achieve world class signal maintenance and operations. Based on this evaluation, the QIT indentified the following six basic barriers to overcome. Current and future resources should be focused on these areas:

1. **Maintenance of signal equipment.** UDOT is in a reactive mode in maintaining its signal equipment. Maintenance of traffic signal equipment must be at a higher level to support world class signal timing and coordination. Proactive maintenance should comprise 70% of UDOT's maintenance activity.
2. **Staffing.** Current staffing (FTE or consultants) is inadequate to support world class signal maintenance and signal operations.
3. **Performance measures.** Performance measures should be used in real-time to monitor and assess the health of the signal system and the quality of operations. In the absence of this capability, signal timing should be redone every 30-36 months.
4. **Expertise in the Regions.** The Regions lack the expertise to fully participate with the TOC in operating the signal system. This leads to miscommunication and pursuit of differing goals. Expertise would ideally be available in the Regions, in addition to the Traffic Management Division.
5. **Policies and procedures.** Expectations for signal operations must be established through policy. UDOT policy does not address maintenance of communication and signal detection during construction, third party, and permit projects. UDOT does not have policies that address operational support for special events and incidents.
6. **Maintenance planning.** UDOT lacks the staffing necessary to plan strategically for signal system maintenance, and lacks an asset management system for signal equipment. Without these two key components, only the most pressing maintenance needs get addressed, and often only at the technician level.
7. **Roles and responsibilities.** UDOT's traffic signal program involves seven UDOT groups. Current roles and responsibilities are not formalized, resulting in gaps and duplications. Clear expectations are needed to ensure the most efficient program.

The balance of this report contains recommendations to overcome these seven barriers.

IV. Roles and Responsibilities

UDOT signal maintenance and operations currently involves three UDOT Divisions within the Operations Group, all four Regions, and consultants. There is some confusion with the current arrangement, which results in the following inefficiencies:

- Some tasks are being duplicated (not always in a consistent manner).
- Some tasks being overlooked or neglected.
- A lack of cohesiveness in approach (inconsistent goals).

In order to eliminate these efficiencies, the QIT recommends formalizing roles and responsibilities. Responsibilities of individual positions are discussed in Section V.

Recommendation #1: The Regions, the Traffic Management Division, the Traffic & Safety Division, and the Central Maintenance Division are formally assigned the roles and responsibilities shown in Table 2.

The QIT also evaluated the potential for each responsibility to be performed by consultants. This allows for the development of options for implementation should FTEs not be available.

Table 2: UDOT Signal Program – Roles and Responsibilities

Role	Responsibility				
	Budgeting	**Signal Maintenance**	**Asset Management**	**Signal Operations**	**Warranting & Construction**
Lead	CM	Regions	Regions	TM	T&S
Support	TM	TM T&S	TM	Regions	Regions
Consultant Potential	None	Low	High	High	Medium

Notes:
'CM' = Central Maintenance Division
'TM' = Traffic Management Division
'T&S' = Traffic and Safety Division

V. Staffing Analysis

CURRENT STAFF

The Department has personnel dedicated to traffic operations in all four regions and in the Traffic Management and Traffic & Safety Divisions. Statewide, there are 29 engineers and 27 technicians dedicated to traffic operations. These engineers and technicians are allocated as follows to the following four general tasks. A summary of UDOT's statewide traffic staff is shown in Table 3.

- 17 to signal maintenance (shown in purple).
- 7 to signal timing and coordination (shown in green).
- 22 to general traffic engineering and design review (shown in blue).
- 10 to signal warranting, design, and construction (shown in yellow).

Table 3: UDOT Traffic Staffing

Region/ Group	# Signals	Operations Engineers	Traffic Engineers	Signal Engineers	Signal Technicians
1	325	EM II	EM I CE III	None	Lead Tech (3)
2	475	EM II	EM I CE III EM I CE III	EM I	Lead Tech (5)
3	225	EM II	EM I CE III	None	Lead Tech (3)
4	100	EM II	EM I CE III CE III	None	Tech Tech
TMD	1,125	EM II EM I EM I CE III		EM I CE III CE III	Lead Tech (3)
T&S		EM II	EM I	EM I	Tech (design) Tech (state-furn) Lead (signal const) Tech (4)
		EM II CE III EM II			

Current staffing does not support the delivery of world class traffic signal maintenance and operations. With only 4 signal engineers focused on signal maintenance and signal timing, UDOT falls short of the recommendation for 1 signal engineer for every 100 signals. The current ratio is 1 signal engineer for every 280 signals. With 20 signal technicians focused on signal maintenance and signal operations, UDOT almost meets the recommendation for one signal technician for every 50 signals. The current ratio is 1 signal technician for every 55 signals.

RECOMMENDED STAFF

The following modifications to staffing are recommended in the Regions and in the Traffic Management Division. In total, 8 new engineering positions are identified. These 8 positions bring the number of engineers focused on signal maintenance and operations of UDOT's 1,125 signals to 12, meeting the minimum ratio recommended in the FHWA Guide of one engineer for every 100 signals.

Organization charts depicting the recommended reporting structures are shown below.

Traffic Management Division: (four new positions)

Recommendation #2: Create a new Traffic Signal Operations Engineer position (Engineer Manager II) that reports to the Division Director.

This elevates traffic signal operations to the program level, which will focus the Traffic Management Division more effectively on signal timing and coordination.

At the program level, this EM II position will:

- Be responsible for traffic signal timing and coordination statewide.
- Perform strategic planning for the statewide traffic signal system, including the traffic signal control software.
- Monitor performance of signal system, identify trends in signal maintenance, and report to senior leadership.
- Recommend guidelines, standards, and policies for statewide signal maintenance and signal operations.
- Be the focal point for communication and coordination between the Traffic Management Division, the Regions, and partner agencies. The EM II will coordinate with the Region Operations Engineers to ensure that the Traffic Management Division is in sync with the Regions.
- Ensure that the Regions receive needed technical support from the Traffic Management Division.
- Manage the signal technicians at the TOC to ensure balanced support for the four UDOT Regions.

Recommendation #3: Create a new Signal Engineer position (Engineer Manager I) and divide the management duties at the EM I level geographically between the existing EM I and the new EM I.

This provides the management and technical expertise to ensure quality statewide traffic signal timing and coordination.

These EM I positions will have the following responsibilities:

- One EM I will focus on signal timing and coordination in Regions 1 and 3, while the other focuses on Regions 2 and 4. This split balances the number of statewide signals evenly.
- Each EM I will serve as a liaison to their assigned Regions for all topics related to signal timing and coordination. The Traffic Management Division will use the model established by Nile Easton's Communications Group and the Regions' Public Involvement Officers. While these two EM I positions will report to the TOC, they will also answer to the Regions. This could be formalized by allowing the Region Operations Engineer to set a portion of the performance plans. This arrangement will increase the Regions' access to the signal timing experts at the TOC by creating a point of contact that has a narrowed geographical focus. This will also facilitate technical mentoring of Region staff by the signal timing experts at the TOC.
- The existing traffic signal detection and traffic signal timing contracts managed by the TOC will be divided geographically by Region. Each EM I will administer the contracts in their assigned Regions.

Recommendation #4: Create two new Civil Engineer III positions that will report to the two EM I positions described above.

These two new CE IIIs will join the existing two CE IIIs to be responsible for:

- Designing traffic signal timing and coordination plans in their assigned Regions.
- Supporting the creation and maintenance of a traffic signal inventory and asset management system.
- Maintenance of a GIS database of statewide traffic signals.
- Reviewing signal designs from an operations perspective.

Benefits. What will be the benefit of these four added positions in the Traffic Management Division? Increased staff will allow all signals in the system to be retimed in approximately 3 years. This will allow the quality of signal timing to be "reset" to optimal operation before delays become excessive, as depicted earlier in Figure 1. Studies, including UDOT's own experience, have shown retiming to have a benefit/cost ratio of 40:1 or more. Reduction in delays due to retiming range from 15 to 40 percent, and fuel consumption is reduced up to 10 percent.

The FHWA Guide estimates that a signal requires about 20 engineering hours to re-time (not including obtaining count data), and that an FTE has 1627 hours of productive time per year. Assume that:

- 4 CE III positions are available, and that 85% of their productive time will be spent on signal timing and coordination (15% spent on special projects, etc.).

- 2 EM I positions are available, and that 40% of their productive time will be spent on signal timing and coordination (60% will be spent on management activities).

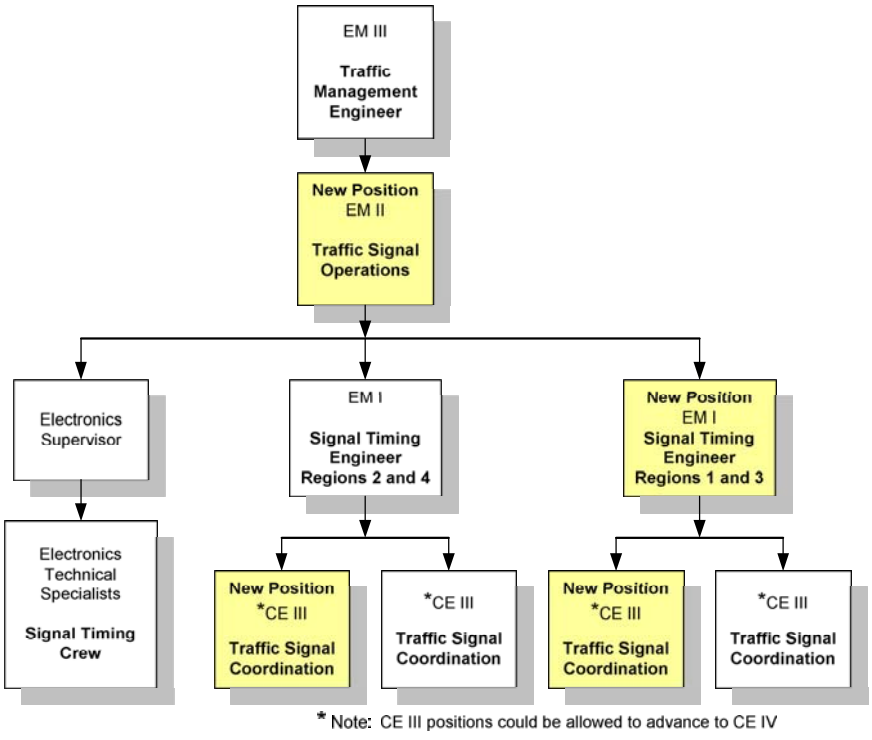
This results in 6,800 hours annually available for signal timing. With 1,125 signals on the system, each requiring 20 hours to retime, 22,500 hours are required system-wide. That means that each signal will be revisited every 3.3 years (22,500/6,800). This does not meet the goal of a 30-month cycle; however, the balance will be addressed through consultants and the signal timing contract currently administered by the TOC.

Recommendation #5: Allow Civil Engineer III staff to progress to Civil Engineer IV.

Civil Engineer III staff could be allowed to progress to Civil Engineer IV as experience and qualification requirements are met. Including the Civil Engineer IV classification in the organization has several benefits:

- It provides a technical track for engineering advancement in signal operations, which will encourage specialization. This is desirable in this highly technical area.
- It increases the likelihood that we will develop and retain expertise.
- It creates a resource to train CE III staff and Region staff at the technical level.
- It helps with span of control at the EM I level.

Recommended Traffic Management Division organization chart (new positions in yellow):



Region 1: (one new position)

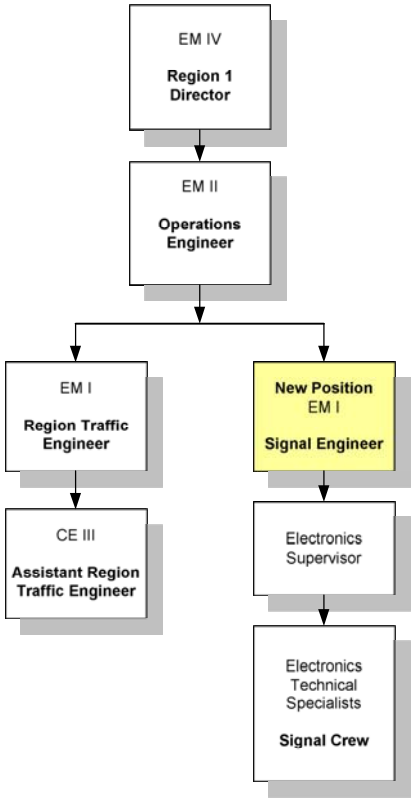
Recommendation #6: Create a new Signal Engineer position (Engineer Manager I) that reports to the Region 1 Operations Engineer.

This new position is similar to the existing Signal Engineer position in Region 2. This EM I will be responsible for:

- Traffic signal maintenance for 325 signals.
- Design review of all traffic signal designs in Region 1.
- Coordination with project managers and permit officers to plan for traffic signal operations during construction, maintenance, and permit projects.
- Performance of proactive signal maintenance.
- Inventory and asset management of traffic signals.
- Supervision of signal technicians.
- Coordination with the Traffic Management Division on signal maintenance and signal operations (timing and coordination) issues.

While primarily focused on signal maintenance, this position will provide the vehicle to develop signal timing expertise in Region 1 by engaging with the TOC at a technical level on signal timing issues.

Recommended Region 1 organization chart (new position in yellow):



Region 2: (one new position)

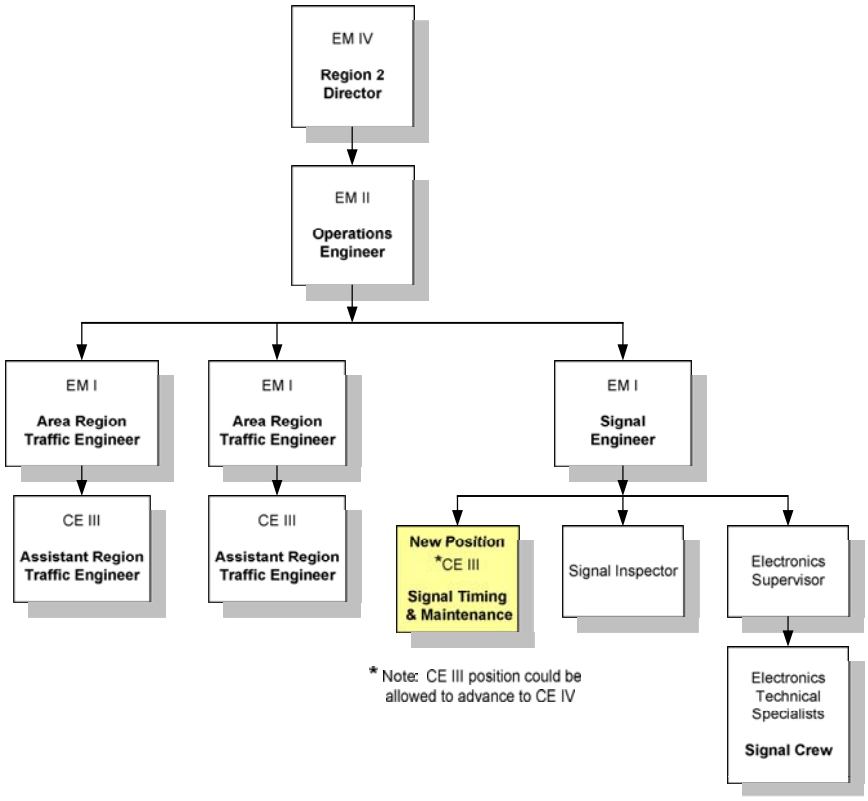
Recommendation #7: Create a new Signal Engineer position (Civil Engineer III) that reports to the Region 2 Signal Engineer.

Region 2 currently has a Signal Engineer (EM I). The Signal Engineer (EM I) currently has more signal maintenance, design review, and construction coordination workload than a single FTE can handle. A second signal engineer is needed to meet all of the maintenance needs, and to engage with the TOC on signal timing and coordination issues. Adding the CE III Signal Engineer position will allow Region 2 to meet the primary expectation listed below, while allowing both time to develop signal timing capability.

The EM I and CE III are responsible for:

- Traffic signal maintenance for 475 signals.
- Design review of all traffic signal designs in Region 2.
- Coordination with project managers and permit officers to plan for traffic signal operations during construction, maintenance, and permit projects.
- Performance of proactive signal maintenance.
- Inventory and asset management of traffic signals.
- Supervision of signal technicians (EM I only).
- Coordination with the TOC on signal maintenance and operations issues.

The traffic organization in Region 2 is as follows (new position in yellow):



Region 3: (one new position)

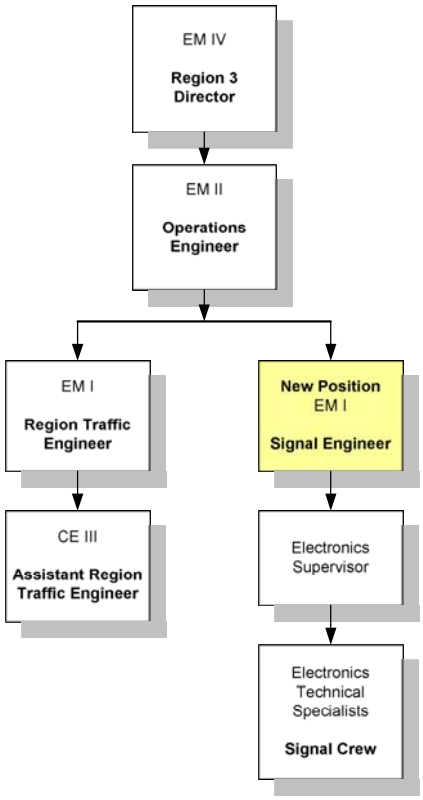
Recommendation #8: Create a new Signal Engineer position (Engineer Manager I) that reports to the Region 3 Operations Engineer.

This new position is similar to the existing Signal Engineer position in Region 2. This EM I will be responsible for:

- Traffic signal maintenance for 225 signals.
- Design review of all traffic signal designs in Region 3.
- Coordination with project managers and permit officers to plan for traffic signal operations during construction, maintenance, and permit projects.
- Performance of proactive maintenance.
- Inventory and asset management of traffic signals.
- Supervision of signal technicians.
- Coordination with the Traffic Management Division on signal maintenance and signal operations (timing and coordination) issues.

While primarily focused on signal maintenance, this position will provide the vehicle to develop signal timing expertise in Region 3 by engaging with the TOC at a technical level on signal timing issues.

Recommended Region 3 organization chart (new position in yellow):



Region 4: (one new position)

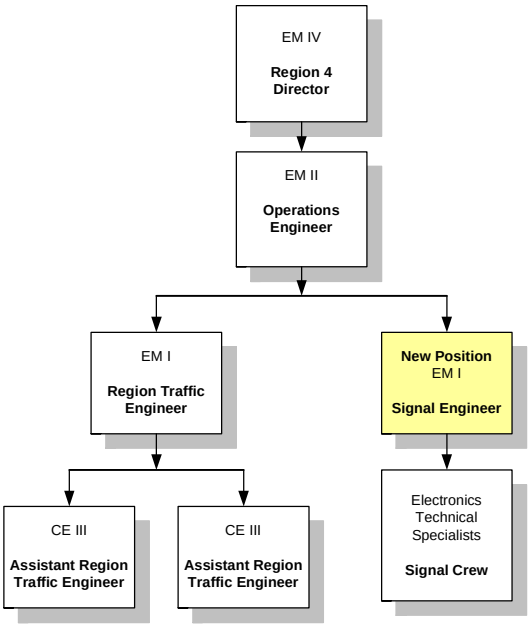
Recommendation #9: Create a new Signal Engineer position (Engineer Manager I) that reports to the Region 4 Operations Engineer.

This new position is similar to the existing Signal Engineer position in Region 2. This EM I will be responsible for:

- Traffic signal maintenance for 100 signals.
- Design review of all traffic signal designs in Region 4.
- Coordination with project managers and permit officers to plan for traffic signal operations during construction, maintenance, and permit projects.
- Performance of proactive maintenance.
- Inventory and asset management of traffic signals.
- Supervision of signal technicians.
- Coordination with the Traffic Management Division on signal maintenance and signal operations (timing and coordination) issues.

While primarily focused on signal maintenance, this position will allow Region 4 to develop signal timing expertise by engaging with the TOC at a technical level. The position is also expected to perform some work traditionally performed by signal technicians. Two technicians covering 100 signals in Region 4 meets the minimum for larger systems, but economy of scale is lost and the geographic spread means that additional signal technician support is needed. Finally, this position will also provide traffic modeling and simulation services within Region Operations. Traffic modeling and simulation goes hand-in-hand with signal timing and coordination, so this combination of duties will be efficient for Region 4.

Recommended Region 4 organization chart (new position in yellow):



VI. Funding Analysis

CURRENT BUDGET

Table 4 shows the annual statewide funding for signal maintenance and signal operations. The Region budgets shown do not include labor or utilities.

Table 4: Current Traffic Signal Operations Annual Budget

Signal Maintenance			
R	Region 1		$ 100,000
R	Region 2		$ 200,000
R	Region 3		$ 55,000
R	Region 4		$ 95,000
TM	Statewide – Signal Detection		$ 2,000,000
TM	Statewide – Signal Controllers/Electronics		$ 375,000
T&S	Statewide – Aging infrastructure		$ 500,000
		Total	$ 3,325,000
Signal Operations (Timing and Coordination)			
TM	Statewide – Signal Timing & Coordination		$ 115,000
TM	Statewide – TOC Signal Desk		$ 110,000
R	Regions – Large UDOT projects		varies
		Total	$ 225,000 +
Signal Design and Construction			
T&S	Statewide – New signal construction		$ 6,500,000
		Total	$ 6,500,000

Notes:
'R' = managed by the Regions.
'TM' = managed by the Traffic Management Division.
'T&S' = managed by the Traffic and Safety Division.

The Traffic and Safety Division has a fixed annual budget of $7,000,000 for traffic signal design and construction. Approximately 7% of that budget is used to upgrade aging signal infrastructure, including poles, mast arms, wiring, and signal heads. This expenditure is shown under maintenance as it is a maintenance activity.

Research reveals that recommended per signal funding levels range from roughly $2,500 per signal per year to $5,000 per signal per year. This seems like a wide range of values until you consider that not all signals systems require detection (closely spaced grid systems such as downtown Portland don't need detection – and detection is estimated at about $2,000 per signal per year). UDOT's calculations show that for signals with detection, $4,500 to $5,000 per year is most appropriate. UDOT's current maintenance funding is just under $3,000 per signal. This appears to at least cover minimal maintenance until we consider that before 2008, the per signal maintenance budget was approximately $1,000 per signal. There is a backlog of unaddressed maintenance at UDOT signals.

RECOMMENDED SIGNAL MAINTENANCE BUDGET

Current funding for signal maintenance is spread over the four Regions and the Traffic Management and Traffic and Safety Divisions. Surprisingly, 86% of current signal maintenance funding (excluding labor and utilities) is currently managed by the Traffic Management and Traffic and Safety Divisions. Because the Operations Group is managing maintenance funds for the Regions, it is appropriate to consider all of the funding for signal maintenance in aggregate.

World class signal operations are dependent on high quality signal maintenance. A signal system that is 95% functional and reliable has progressed to the point where 70% of maintenance resource is spent on proactive or preventative maintenance. Proactive signal maintenance means replacing or repairing devices before they reach the end of their useful life and experience equipment failure. Key proactive signal maintenance items include:

- Signal detection.
- Signal controllers.
- Signal cabinet.
- Various electronics in the cabinet.
- Pedestrian signals.
- Signal lenses (LEDs).
- Aging infrastructure.

A program to systematically replace these must consider the cost to replace, the life cycle of the device, and the number of installations. Table 5 shows the development of an annual budget to address the proactive maintenance of these items on all 1,125 UDOT signals statewide. This budget number is for statewide signal maintenance, and would be distributed between the Regions, the Traffic Management Division, and the Traffic and Safety Division. Region funding would be divided according to the proportion of statewide traffic signals in each Region.

Recommendation #10: Establish the statewide signal maintenance budget based on proactive maintenance, as shown in Table 5.

Allocating $4.855 million for the signal maintenance of 1,125 statewide traffic signals results in a per signal expenditure of $4,300. This is close to the recommended range of $4,500 to $5,000 per signal.

Table 5: Development of Recommended Signal Maintenance Budget

		Life Cycle (yrs)	Cost / Signal	Cost / Signal / Year	Recommended Annual Budget [a]
Signal Maintenance – Recurring					
TM	Detection	10	$ 20,000	$ 2,000	$ 2,250,000
TM	Controllers/Electronics	10	$ 24,000	$ 2,400	$ 315,000
T&S	Aging infrastructure	n/a	n/a	n/a	$ 500,000
R	Signal cabinets	15	$ 6,500	$ 433	$ 490,000
R	Electronics in cabinet	10	$ 4,000	$ 400	$ 360,000
R	Pedestrian signals	8	$ 1,600	$ 200	$ 225,000
R	LED replacement	8	$ 2,400	$ 300	$ 340,000
R	Knock downs, failures	3 [b]	$ 1,000	$ 333	$ 375,000
				Annual Total	$ 4,855,000

Notes:
'R' = managed by the Regions.
'TM' = managed by the Traffic Management Division.
'T&S' = managed by the Traffic and Safety Division.
'a' – Recommended Annual Budget = (cost/signal/year)x(1,125 signals statewide).
'b' – Assume that in 3 years there will be $1,000 needed at all 1,125 signals.

RECOMMENDED SIGNAL OPERATIONS BUDGET

Funding for signal operations is recommended in 4 areas, 2 of which are existing budget line items.

- TOC Signal Desk coverage (existing).
- Traffic signal timing and coordination contract (existing).
- Traffic counts to support signal timing and coordination (new).
- Low-cost signal improvements for safety and operations (new).

TOC Signal Desk

The TOC Signal Desk is where UDOT monitors and reacts to real-time traffic congestion by adjusting traffic signal timing. The majority of this work is performed by consultants. Current coverage is as follows:

- 30 hours/week – consultant.
- 10 hours/week – TOC staff.
- 40 hours/week – I-15 CORE staff.

The current coverage is adequate, but is temporary. When the CORE project ends, coverage reverts back to the previous level of 30 contracted hours/week, supplemented by 10 hours/week from TOC staff. This coverage is not adequate to actively manage traffic signal operations on a daily basis.

Coverage at the TOC Signal Desk should be increased from 30 to 60 contracted hours per week, supplemented by 20 hours per week by the expanded TOC staff. This will provide weekday coverage from 6am to 8pm and Saturday coverage from 10am to 8pm.

UDOT's current budget for this contract is $110,000, which is unchanged since its inception in 2003. This should be increased to $250,000 to account for doubling the hours and for wage increases since the program began approximately 10 years ago.

Signal Timing and Coordination Contract
The Traffic Management Division manages an annual contract to have a consultant provide signal timing and coordination services. The consultant allows UDOT to leverage its staff to address more signal timing needs.

The current budget for this contract is $115,000. The budget for this item hasn't changed since its inception 10 years ago. The budget for this item should be doubled to $230,000. This increase will allow UDOT to meet the 30-month retiming cycle, and will provide contracted support for signal operations for large civic events by creating customized signal timing plans, and by providing necessary field and TOC support during civic events.

Traffic Counts
The development of traffic signal timing and coordination plans requires count data. Current practice is to work with limited count data and use judgment to fill in any gaps. This saves on budget, but does not give the signal timing engineer the data necessary to develop optimal coordination plans. A new funding source for traffic counts is recommended to fill this gap.

If all 1,125 signals are retimed every 30 months, 450 signals will be retimed per year. However, not all coordination plans require count data. Assume that:

- 50% of signals will require counts. This workload will be split 80/20 between consultants and Traffic and Safety (T&S currently provides count data).
- Each intersection requires 8 hours to collect data.
- Average consultant/technology cost of $62.50/hr.

UDOT should budget approximately $90,000 per year to collect count data in support of traffic signal timing and coordination.

Contractors can perform this work, or the data can be gathered using technology.

Low-Cost Operational and Safety Improvements
The QIT also considered the benefit of making low-cost safety and operational improvements at traffic signals that would positively impact capacity and the quality of signal operations. Similar to the Safety Spot Improvement Program, these funds would be used to make targeted, low-cost improvements with high benefit/cost ratios, with the focus on right-turn overlaps and flashing yellow arrows for left turns.

This would be a new program that would be managed by the Regions, with input and support from the Traffic Management Division. It is estimated that all eligible locations could be addressed within 10 years, at which time the program could be re-evaluated. The benefit of this program will increase as congestion increases.

Table 6 shows the recommended budget for Signal Operations.

Recommendation #11: Establish the statewide signal operations budget as shown in Table 6.

Table 6: Development of Recommended Signal Operations Budget

		Life Cycle (yrs)	Cost / Signal	Cost / Signal / Year	Number of Signals	Recommended Annual Budget
Signal Operations – Recurring						
TM	TOC Signal Desk	1	n/a	n/a	n/a	$ 250,000
TM	TOC Signal Timing	1	n/a	n/a	n/a	$ 230,000
TM	TOC Traffic Counts	1	$ 500	$ 500	180	$ 90,000
					Total	$ 570,000
Signal Operations – Low Cost Improvements						
R	Right turn overlaps	10	$5,000	$ 500	225	$ 110,000
R	Flashing yellow arrow	10	$5,000	$ 500	75	$ 40,000
					Total	$ 150,000

Notes:
'R' = managed by the Regions.
'TM' = managed by the Traffic Management Division.

COMPARISON OF CURRENT vs RECOMMENDED BUDGETS

Table 7 shows a comparison of current versus recommended signal maintenance and signal operations budgets. The recommended budget is increased by 57% over the current budget.

It is important to note that the recommended budget will align the Department with the goal to be performing proactive vs. reactive maintenance, and will result in a system with a high degree of device reliability. This level of signal maintenance creates the environment where signal timing and coordination can really pay dividends.

Recommendation #12: Divide the recommended statewide signal maintenance and signal operations budgets in Table 7 that are managed by the Region according to the percentage of statewide traffic signals in each Region.

Table 7: Current vs. Recommended Traffic Signal Operations Budgets			
		Current	**Recommended**
Signal Maintenance – Recurring			
TM	Detection	$ 2,000,000	$ 2,250,000
TM	Controllers/Electronics	$ 375,000	$ 315,000
T&S	Aging infrastructure	$ 500,000	$ 500,000
R	Signal cabinets	$ 0	$ 490,000
R	Electronics in cabinet	$ 0	$ 360,000
R	Pedestrian signals	$ 0	$ 225,000
R	LED replacement	$ 0	$ 340,000
R	Knock downs, failures	$ 450,000	$ 375,000
	Total	$ 3,325,000	$ 4,855,000
Signal Operations – Recurring			
TM	TOC Signal Desk coverage	$ 110,000	$ 250,000
TM	TOC Signal timing and coordination	$ 115,000	$ 230,000
TM	TOC Traffic counts for signal timing	$ 0	$ 90,000
	Total	$ 225,000	$ 570,000
Signal Operations – Low Cost Improvements (10 year sunset)			
R	Right-turn overlaps	$ 0	$ 110,000
R	Flashing yellow arrows	$ 0	$ 40,000
	Total	$ 0	$ 150,000
	Annual Total	$ 3,550,000	$ 5,575,000

Notes:
'R' = managed by the Regions.
'TM' = managed by the Traffic Management Division.
'T&S' = managed by the Traffic and Safety Division.

VII. Other Recommendations

The QIT has the following additional recommendations to elevate UDOT's traffic signal maintenance and operations to world class:

SIGNAL OPERATIONS DURING CONSTRUCTION

Signal operations are of critical importance during construction because capacity is often constrained by lane closures or lane geometry. To support world class signal timing and coordination during construction, two things are critical: signal detection must remain operational; and communications between the TOC and the signals in the workzone must be maintained. With these tools, the TOC can support projects to minimize workzone delay.

Recommendation #13: Require that construction, third party, and permit projects maintain signal detection and maintain communications with the TOC. Require that new signals be fully operational before turn-on.

SIGNAL OPERATIONS DURING SPECIAL EVENTS

Large special events create localized increases in traffic demand. These events require unique signal timing plans to be created, and usually require staff to be present during the event to monitor and react to changing traffic conditions.

Recommendation #14: Develop a guideline to determine the threshold for special events to be supported by the TOC. Utilize increase in recommended Signal Operations funding to use consultants to provide engineering and field support.

MAINTENANCE OF AGING INFRASTRUCTURE

Traffic and Safety currently uses about 7% of its annual budget on upgrading aging traffic signal infrastructure. Aging infrastructure includes poles, mast arms, wiring, conduit, junction boxes, and signal heads. The magnitude of the need for infrastructure maintenance is unknown at this time. An evaluation should be performed to determine remaining useful life, and to create a plan to address impending replacements. The evaluation will involve the Regions, Traffic and Safety, Traffic Management, Central Maintenance, and Structures.

Recommendation #15: Evaluate UDOT's existing traffic signal infrastructure to determine remaining useful life. Create a plan for proactive maintenance.

STAFF QUALIFICATIONS

To obtain the PTOE an engineer must be a licensed PE, have four years of traffic operations engineering experience, and must pass a test administered by the Transportation Professional Certification Board. As of June 2010 there were 2,400 certified PTOEs nationwide. Of those, 30 reside in Utah and 11 work for UDOT.

The PTOE certification has become an accepted means to establish competency in Traffic Operations. Obtaining this certification is a powerful demonstration of the requisite knowledge, skill and ability in the specialized application of traffic operations engineering. All signal engineers at UDOT, EM I and above, should be a PTOE or obtain certification within 12 months of starting in the position.

Recommendation #16: Require that all traffic signal engineers, EM I and above, be certified as a Professional Traffic Operations Engineer (PTOE) by the Transportation Professional Certification Board.

The QIT identified that expertise must be developed in the Regions, and that signal operations is a highly technical field that requires specialization beyond even PTOE certification. On-going training will ensure that expertise is developed and that signal engineers are well-equipped to provide world class signal operations.

Recommendation #17: Develop a training program for Signal Engineers that focuses on traffic signal maintenance and traffic signal operations.

Supervisors of signal technicians should demonstrate technical expertise and capability by becoming Level III certified by the International Municipal Signal Association (IMSA). This will ensure capable supervision and support safety.

Recommendation #18: Require that all signal technician supervisors be Level III certified by the International Municipal Signal Association (IMSA).

POOLED-FUND STUDY

The Indiana Department of Transportation is leading the "Traffic Signal Systems Operations and Management" pooled-fund study to:

- Develop consensus on operational standards of performance.
- Define a central management model that can leverage commercial wireless IP offerings that can be competitively outsourced.
- Develop management principles for using a central system to identify when and where resources are most needed to maximize return on investment.

The QIT identified the need to monitor system performance and health in real-time. This pooled fund study aims to assist agencies in accomplishing this task. $25,000 per year is requested to participate, but a one-time contribution is also acceptable. Details are available at http://pooledfund.org/ (Study # 1296).

Recommendation #19: Participate in the Indiana DOT's "Traffic Signal Systems Operations and Management" pooled fund study. Implement real-time monitoring of system health and the quality of signal operations.

STEWARDSHIP OF PUBLIC TRUST

Good signal timing is not immediately obvious to the average driver, but most can recognize bad signal timing or detection. The basics of signal timing and UDOT's efforts to improve signal timing should be communicated with the public. This will increase public confidence in UDOT and manage expectations.

The following are some ideas for raising public perception of signal timing issues.

- All signal timing crews in the field should place an orange, construction-style sign saying "Signal Timing In Progress" or similar.
- Publish a route map for metropolitan areas showing the favored direction of signal timing by time of day.
- Publicize the TOC signal desk as a place to report signal complaints.
- Publish an annual report detailing signal timing efforts and results.
- Work to increase media awareness of signal timing – through contacts with traffic reporters, exposure on special events, etc.

Recommendation #20: Develop methods of public outreach to demonstrate the need for and effectiveness of signal detection and signal timing.

VIII. Options for Implementation

The QIT was also asked to evaluate options for achieving implementing the QIT recommendations. Three options are presented. Each could be further customized. A summary and comparison of the three options is included at the end of this Section.

OPTION 1: WORLD CLASS THROUGH UDOT FTEs

This option provides world class signal maintenance and operations by adding UDOT FTEs and increasing maintenance funding as described in the body of the QIT report. To recap, this option involves:

- Adding a total of eight new FTEs as follows:
  - Three new EM I Signal Engineer positions, one in Region 1, one in Region 3, and one in Region 4. With the existing EM I Signal Engineer position in Region 2, the region management structure will be in place to support world class signal maintenance, and facilitate coordination with construction, third-party, and permit projects.
  - One new CE II Signal Engineer position in Region 2. The 475 signals in Region 2 are too many for one Signal Engineer.
  - One new EM II Signal Operations Engineer at the TOC. This elevates signal operations to the program level and will facilitate the statewide management and coordination to operate and maintain signals efficiently.
  - One new EM I Signal Timing Engineer position at the TOC, joining the existing EM I Signal Timing Engineer. This allows the state to be divided geographically by Region, and assigns the TOC resources necessary to focus on region issues.
  - Two new CE III positions at the TOC, one each to report to the EM I positions described above. These two new positions join 2 existing CE III positions. Each EM I will manage two CE III positions focused on signal timing, coordination, and asset management.
- Increasing the statewide signal maintenance and operations budget by $2.025 million to $5.575 million.

OPTION 2: WORLD CLASS THROUGH CONSULTANTS

This option is designed to produce the same results as Option #1, except that added FTEs are minimized through the use of consultants. This option involves:

- Adding a total of 2 new FTEs as follows:
  - 2 new EM I Signal Engineer positions, one in Region 1 and one in Region 3.
- Temporarily using 2 FTEs at the TOC to fill new EM II Signal Operations Engineer and EM I Signal Timing Engineer positions. These 2 positions will be returned to Leadership as soon as vacancies at the TOC allow. The intended result is for the 3 existing positions at the TOC to transition from one EM I and two CE IIIs to one EM II and two EM Is. This transition may take some time.
- Increasing the statewide signal maintenance and operations budget by $2.975 million to $6.525 million. This increase provides the following consultant support:

- Provides funding for consultants to provide signal timing and coordination services at the TOC. Consultants will provide the equivalent of 4 CE III Signal Timing Engineers at the TOC, and will be managed by the upgraded management structure at the TOC described in the bullet above.
- Provides funding for a consultant to provide support to the Region 2 Signal Engineer. The consultant will provide the equivalent of 1 CE III Signal Engineer.
- Provides funding for a consultant to act as the Region 4 Signal Engineer. The consultant will provide the equivalent of ½ EM I Signal Engineer.

This option minimizes, but does not eliminate new UDOT FTEs. The two new positions in Regions 1 and 3 are viewed as essential because the positions will:

- Be responsible for prioritizing and spending money on signal maintenance and will manage budgets, which could create conflict of interest.
- Be required to coordinate with construction, third-party, and permit projects, as well as other groups internal to UDOT. A consultant would likely not get the respect necessary to function adequately.
- Supervise UDOT personnel.
- Represent the Department in coordinating with cities and counties.
- Serve on equipment and consultant selection committees.

OPTION 3: INCREMENTAL STEPS TO WORLD CLASS

This option offers a management plan to minimize costs while incrementally moving UDOT toward world class signal maintenance and operations. The basic philosophy of the incremental plan is that signal maintenance must come first. Signal timing is most effective on a functioning system. Once the serious maintenance issues have been addressed, then funding should be added to implement the QIT recommendations for signal timing and coordination (whether accomplished through Option 1 or Option 2).

Two phases are identified in this option, as outlined below.

Phase 1: Focus on Signal Maintenance

A focus on signal maintenance is necessary to establish the environment where signal operations can flourish. Phase 1 will prioritize signal maintenance over signal operations for a period of 3-5 years. During this time, resources are added to signal maintenance while resources for signal operations remain at current levels. Phase 1 will consist of the following:

- Add 2 new EM I Signal Engineer positions, one each for Region 1 and 3. These positions, and the existing Region 2 EM I Signal Engineer, will be responsible for managing signal maintenance activities for 91% of the state's signals. These two new positions will be permanent.
- Add the equivalent of an EM I Signal Engineer in Region 4 through consultants (1000 hours per year).
- Create a new EM II Signal Operations position at the TOC. This position will be returned to Leadership as soon as vacancies at the TOC allow.

- Prioritize all or most available funds (up to QIT recommended limits) on maintenance.
- Maintain current funding and resources at the TOC for signal timing and coordination.

Phase 2: Balanced focus on Maintenance and Signal Timing
The percentage of signals with working detection and up-to-date maintenance will increase. In roughly 3-5 years, resources should be added to implement Option 1 or 2, resulting in a balanced approach to signal maintenance and signal operation. Options 1 and 2 will likely be adjusted to reflect lessons learned during Phase 1.

This guideline should function at any funding level – the variable is the time for Phase 1.

COMPARISON OF IMPLEMENTATION OPTIONS

Table 8 shows the recommended budgets and FTEs for Options 1, 2, and 3.

Table 8: Budget Summary for Options

	Current	Option 1	Option 2	Option 3 (Phase 1)
Signal Maintenance	$ 3.325 M	$ 4.855 M	$ 4.855 M	$ 4.855 M
Signal Operations – Consultants	$ 0.225 M	$ 0.570 M	$ 1.520 M[a]	$ 0.325 M[b]
Signal Operations – Equipment	$ 0	$ 0.150 M	$ 0.150 M	$ 0.150 M
Total	$ 3.550 M	$ 5.575 M	$ 6.525 M	$ 5.330 M
UDOT FTEs	4	12	6	6

Notes:
'a' = includes "Option 1" plus consultant equivalent of 5½ UDOT FTEs ($950k); Assume 1700 hours for 5 CE III; Assume 1000 hours for Region 4 EM I; Assume $100/hr avg.
'b' = includes "Current" plus consultant equivalent of ½ UDOT FTE ($100k); Assume 1000 hours for Region 4 EM I; Assume $100/hr avg.

Table 9 shows the change in recommended budgets and FTEs for Options 1, 2, and 3 versus Current.

Table 9: Change in Budget for Options vs. Current

	Current	Option 1	Option 2	Option 3 (Phase 1)
Signal Maintenance	-	$ 1.530 M	$ 1.530 M	$ 1.530 M
Signal Operations – Consultants	-	$ 0.345 M	$ 1.295 M	$ 0.100 M
Signal Operations – Equipment	-	$ 0.150 M	$ 0.150 M	$ 0.150 M
Total	-	$ 2.025 M	$ 2.975 M	$ 1.780 M
UDOT FTEs	-	+8	+2	+2